

In-Space Propulsion Data Sheets

Updated: 4/8/20

Package cleared for public release

Monopropellant Propulsion



> 17,000 flight monopropellant thrusters delivered





MR-103 0.2 lbf REA



MR-111 1.0 lbf REA



MR-106 5.0 lbf REA



MR-107 60 lbf REA



MR-104 100 lbf REA



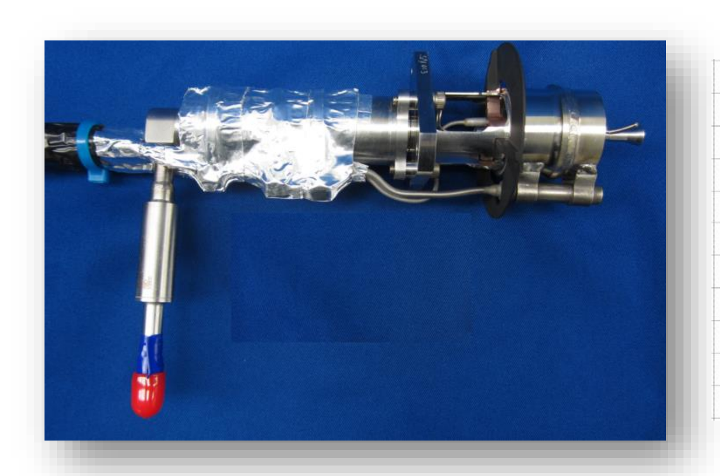
MR-80 700 lbf REA

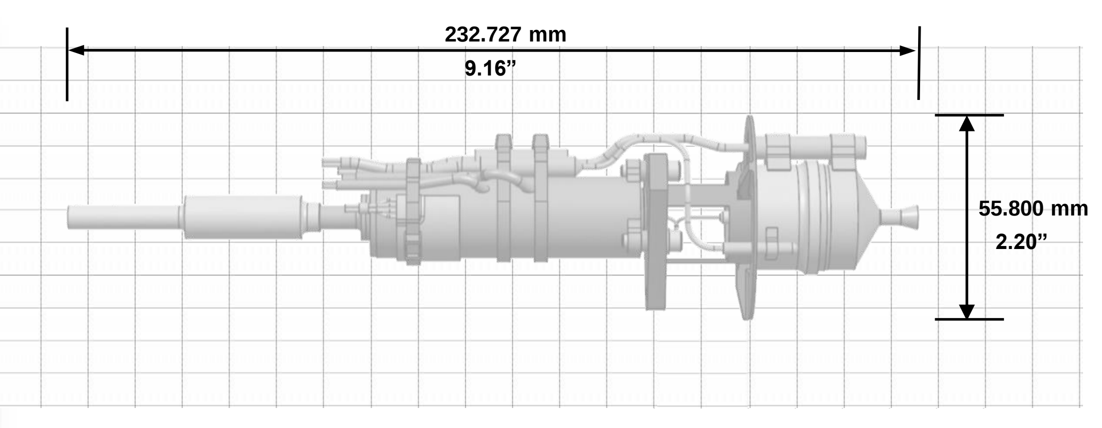
Aerojet Rocketdyne produces monopropellant rocket engines with thrust ranges from 0.02 lbf to 600 lbf

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MR-401 0.09 N (0.02 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant……………………………………………… Hydrazine
- Catalyst……………………………………………….... S-405
- Thrust/Steady State………..0.07 – 0.09 N (0.016 - 0.020 lbf)
- Feed Pressure………………14.8 – 18.6 bar (215 - 270 psia)
- Flow Rate……… 154.2 – 181.4 g/hr (0.34 – 0.40 lbm/hr)
- Valve………………………………………………… Dual Seat
- Valve Power…………….. 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power……. 1.9 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 1.8 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………… 0.60 kg (1.32 lbm)
  - Engine……………………………… 0.33 kg (0.74 lbm)
  - Valve………………………………… 0.20 kg (0.44 lbm)
  - Heaters…………………………… 0.065 kg (0.14 lbm)

Performance

- Specific Impulse, steady state……. 180 - 184 sec (lbf-sec/lbm)
- Specific Impulse, cumulative……...1 50 - 177 sec (lbf-sec/lbm)
- Total Impulse…………………. 199,693 N-sec (44,893 lbf-sec)
- Total Starts/Pulses……………………………………… ..5,960
- Min Impulse Bit………… 4.0 N-sec @ 14.8 bar & 60 sec ON
  ………………………… (0.9 lbf-sec @ 215 psia & 60 sec ON)
- Steady State Firing.................. 0 - 900 sec Single Firing
  ……………………………… 720 hrs Cumulative

Status

- Flight Proven
- Currently in Production

Reference

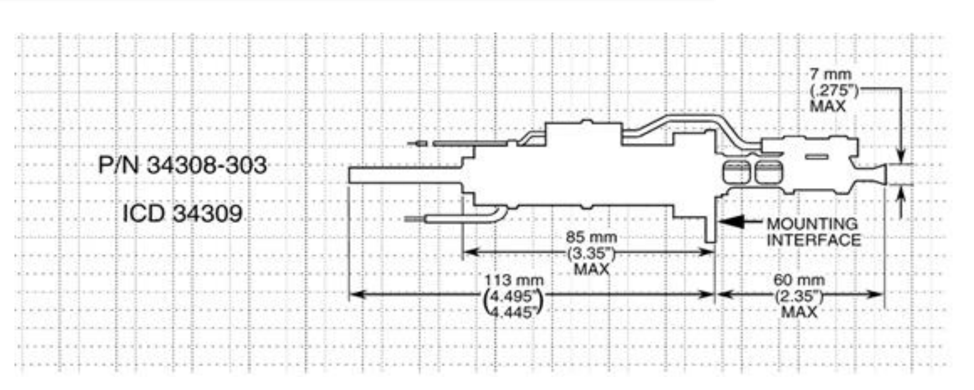
- JANNAF, 2011, paper 2225

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MR-103G 1N (0.2 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant…………………………………………… Hydrazine
- Catalyst……………………………………………….. S-405
- Thrust/Steady State……….. 1.13 - 0.19 N (0.253 - 0.043 lbf)
- Feed Pressure…………….. 28.3 - 4.8 bar (420 - 70 psia)
- Chamber Pressure………….. 23.8 - 4.5 bar (345 - 65 psia)
- Expansion Ratio……………………………………....... 100:1
- Flow Rate……… 0.5 - 0.09 g/sec (0.0011 - 0.0002 lbm/sec)
- Valve…………………………………………………. Dual Seat
- Valve Power…………….. 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power……. 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 6.32 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………. 0.33 kg (0.73 lbm)
  - Engine………………………………. 0.13 kg (0.24 lbm)
  - Valve…………………………………. 0.20 kg (0.44 lbm)
  - Heaters……………………………… 0.033 kg (0.14 lbm)

Performance

- Specific Impulse…………………… 224 - 202 sec (lbf-sec/lbm)
- Total Impulse………………… 97,078 N-sec (21,825 lbf-sec)
- Total Pulses…………………………………………… 835,017
- Min Impulse Bit………… 0.0133 N-sec @ 6.9 bar & 15 ms ON

  ………………………… (0.003 lbf-sec @ 100 psia & 15 ms ON)
- Steady State Firing........... 300 & 1,000 sec Single Firing

  ……………………………… 23.8 — 40.6 hrs Cumulative

Status

- Flight Proven
- Currently in Production; Transitioning to MR-103J

Reference

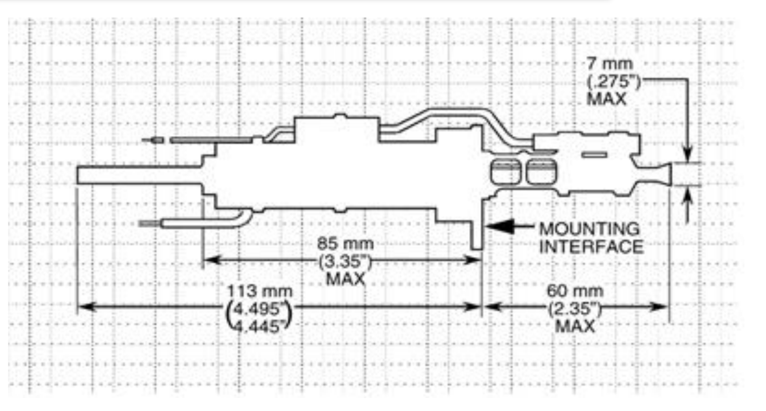
- AIAA-2005-3952

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MR-103J 1N (0.2 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant………………………………………… Hydrazine
- Catalyst…………………………………………….. S-405
- Thrust/Steady State……….. 1.13 - 0.19 N (0.253 - 0.043 lbf)
- Feed Pressure……………… 28.3 - 4.8 bar (420 - 70 psia)
- Chamber Pressure…………… 23.8 - 4.5 bar (345 - 65 psia)
- Expansion Ratio……………………………………....... 100:1
- Flow Rate……… 0.5 - 0.09 g/sec (0.0011 - 0.0002 lbm/sec)
- Valve……………………………………………… Dual Seat
- Valve Power…………… .. 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power……. 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 6.32 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………. 0.37 kg (0.82 lbm)
  - Engine………………………………. 0.11 kg (0.24 lbm)
  - Valve…………………………………. 0.20 kg (0.44 lbm)
  - Heaters………………………………. 0.065 kg (0.14 lbm)

Performance

- Specific Impulse…………………… 224 - 202 sec (lbf-sec/lbm)
- Total Impulse………………… 183,000 N-sec (41,000 lbf-sec)
- Total Pulses…………………………………………… .1,002,345
- Min Impulse Bit………… 0.0133 N-sec @ 6.9 bar & 15 ms ON
  ………………………… (0.003 lbf-sec @ 100 psia & 15 ms ON)
- Steady State Firing..................... 3,600 sec Single Firing
  …………………………………………......... 84hrs Cumulative

Status

- Qualified; First Flight in 2020
- Currently in Production

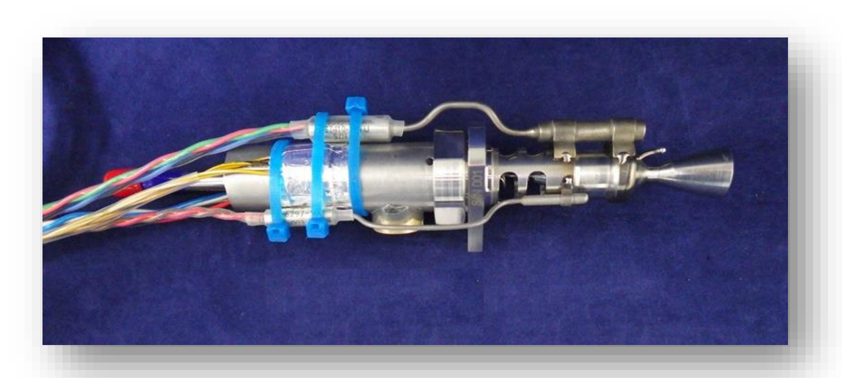
Reference

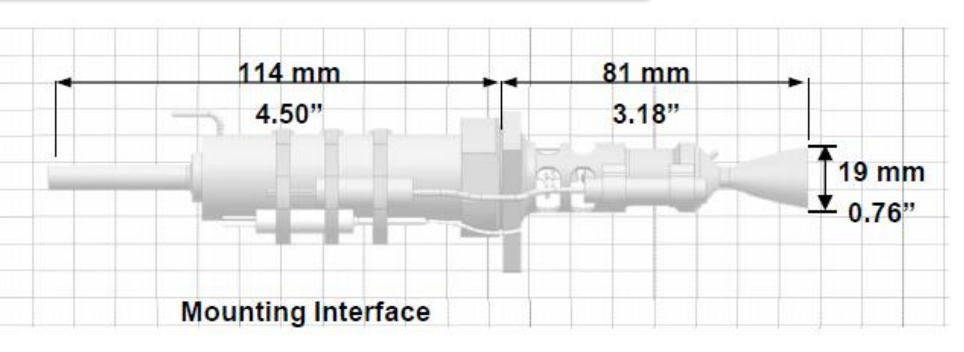
- AIAA-2016-4980

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MR-111G 4N (1.0 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant………………………………………… Hydrazine
- Catalyst……………………………………………….. S-405
- Thrust/Steady State…………....... 4.9 - 1.8 N (1.1 - 0.4 lbf)
- Feed Pressure……………… 24.1 - 6.7 bar (350 - 100 psia)
- Chamber Pressure…………. 10.0 - 3.7 bar (145 - 54 psia)
- Expansion Ratio………………………………......... 74:1
- Flow Rate……… 2.0 - 0.77 g/sec (0.0044 - 0.0017 lbm/sec)
- Valve………………………………………………. Dual Seat
- Valve Power…………….. 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power… 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Power….6.32 Watts Max @ 28 Vdc & 21°C
- Mass………………………………………. 0.37 kg (0.82 lbm)
    - Engine……………………………... 0.11 kg (0.24 lbm)
    - Valve………………………………. 0.20 kg (0.44 lbm)
    - Heaters……………………………0.065 kg (0.14 lbm)

Performance

- Specific Impulse……………………. 229 - 219 sec (lbf-sec/lbm)
- Total Impulse………………… 262,000 N-sec (59,000 lbf-sec)
- Total Pulses………………………………………………. 420,000
- Min Impulse Bit………… 0.076 N-sec @ 15.5 bar & 20 ms ON
- …………………………(0.017 lbf-sec @ 225 psia & 20 ms ON)
- Steady State Firing..... 10,000 sec demonstrated - Single Firing

Status

- Flight Proven
- Currently in Production

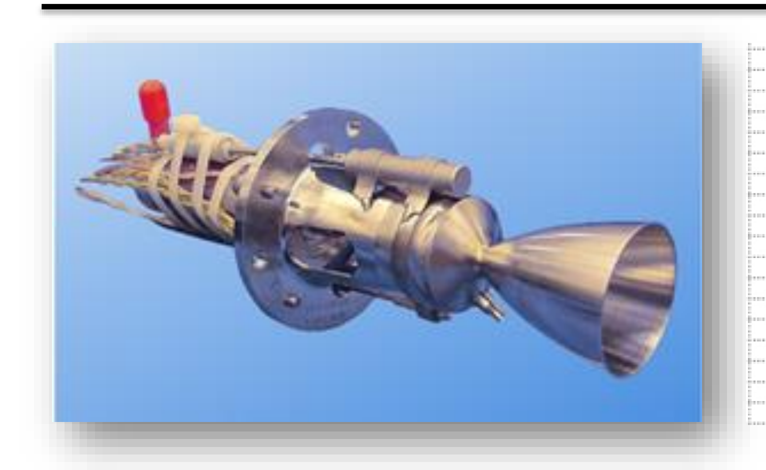
Reference

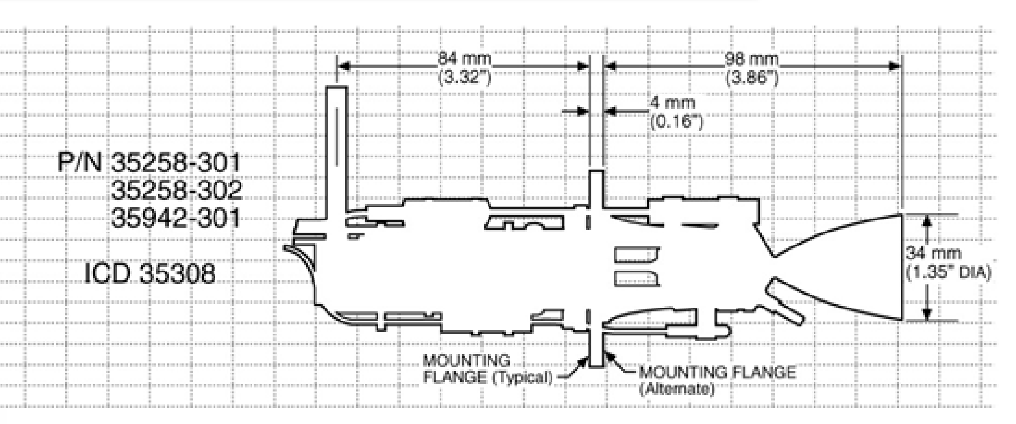
- AIAA-2012-3817

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MR-106L 22N (5.0 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant………………………………………… Hydrazine
- Catalyst……………………………………… S-405/LCH-202
- Thrust/Steady State……….……… 34 - 10 N (7.7 - 2.3 lbf)*
- Feed Pressure……………… 27.6 - 5.9 bar (400 - 85 psia)
- Chamber Pressure……………13.4 – 3.8 bar (195 – 56 psia)
- Expansion Ratio……………………………………........ 60:1
- Flow Rate……… 14.0 – 4.1 g/sec (0.031 - 0.009 lbm/sec)
- Valve………………………………………………… Dual Seat
- Valve Power……………... 25.1 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power……. 4.00 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 7.06 Watts Max @ 28 Vdc & 21°C
- Mass…………………………………….0.59 kg (1.14 lbm) Nom

Performance

- Specific Impulse…………………….235 - 228 sec (lbf-sec/lbm)
- Total Impulse……………… 561,388 N-sec (126,205 lbf-sec)
- Total Pulses…………………………………………….120,511
- Min Impulse Bit………… 0.015 N-sec @ 5.9 bar & 16 ms ON
  ………………………… (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing..........................4,000 sec Single Firing

Status

- Flight Proven
- Currently in Production

Reference

- AIAA-2005-3954

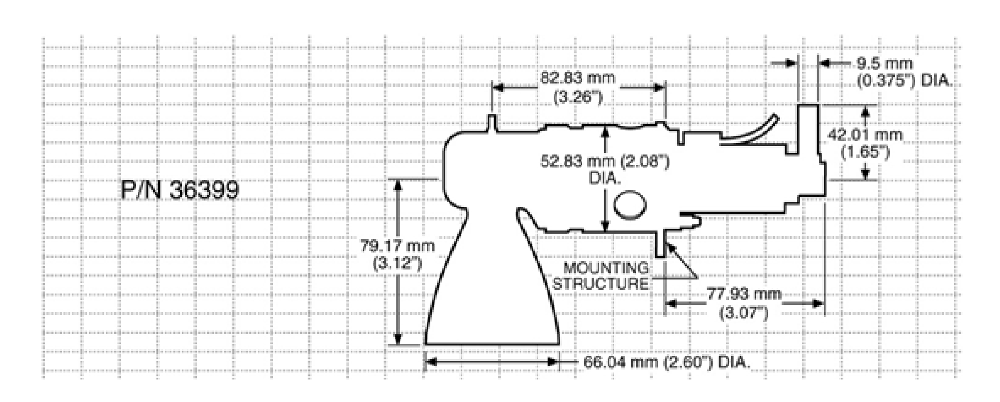
** Note: thrust levels up to 9lbf have been qualified and flown*

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MR-107T 110N (25 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant………………………………………… Hydrazine
- Catalyst……………………………………… S-405/LCH-202
- Thrust/Steady State……….......……… 125 - 54 N (28 - 12 lbf)
- Feed Pressure…………………... 35 - 7 bar (500 - 100 psia)
- Chamber Pressure………………..4.7 – 1.8 bar (69 - 26 psia)
- Expansion Ratio…………………………………..... 21.5:1
- Flow Rate……… 55.8 – 22.7 g/sec (0.125 - 0.05 lbm/sec)
- Valve…………………………………………… Single Seat
- Valve Power……………... 34.8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power……. . 4.0 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 13.2 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………. 1.01 kg (2.23 lbm)
  - Engine………………………………... 0.67 kg (1.48 lbm)
  - Valve…………………………………. 0.34 kg (0.75 lbm)
  - Heaters…………………………… 0.065 kg (0.14 lbm)

Performance

- Specific Impulse……………………. 222 - 225 sec (lbf-sec/lbm)
- Total Impulse…………………. 162,360 N-sec (36,500 lbf-sec)
- Total Pulses…………………………………………… 36,500
- Min Impulse Bit………… 0.015 N-sec @ 5.9 bar & 16 ms ON
- ……………………… (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing........................... 100 sec @ 125 N (28 lbf)
  …………………………………...... 100 sec @ 54 N (12 lbf)

Status

- Flight Proven
- Currently in Production

Reference

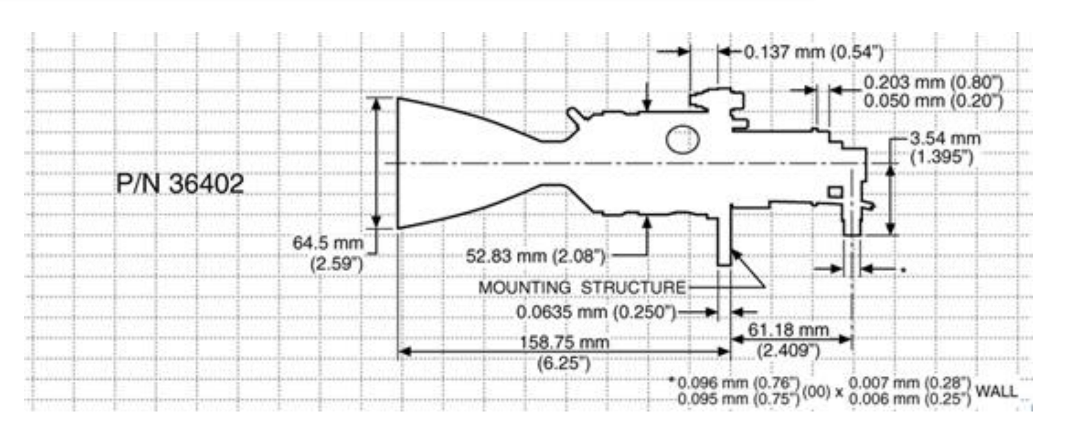
- AIAA-2012-3817

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MR-107S 275N (60 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant……………………………………………… Hydrazine
- Catalyst……………………………………… S-405/LCH-202
- Thrust/Steady State………..……… 360 - 85 N (81 - 19 lbf)
- Feed Pressure………………….. 35 - 7 bar (500 - 100 psia)
- Chamber Pressure……………….. 14 - 4 bar (197 - 45 psia)
- Expansion Ratio…………………………………….... 21.5:1
- Flow Rate……… 154.7 – 36.3 g/sec (0.341 - 0.08 lbm/sec)
- Valve……………………………………………… Single Seat
- Valve Power…………….... 34.8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power……. . 4.0 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 13.2 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………. 1.01 kg (2.23 lbm)
  - Engine……………………………….. 0.67 kg (1.48 lbm)
  - Valve…………………………………. 0.34 kg (0.75 lbm)
  - Heaters……………………………… 0.065 kg (0.14 lbm)

Performance

- Specific Impulse…………………….225 - 236 sec (lbf-sec/lbm)
- Total Impulse…………………. 337,620 N-sec (75,900 lbf-sec)
- Total Pulses……………………………………………… 30,300
- Min Impulse Bit………… 0.015 N-sec @ 5.9 bar & 16 ms ON
  ………………………… (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing.......................... 41 sec @ 360 N (81 lbf)
  ……………………………………….... 30 sec @ 285 N (64 lbf)
  …………………………………….... 100 sec @ 236 N (53 lbf)

Status

- Flight Proven
- Currently in Production

Reference

- AIAA-2012-3817

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MR-107U 300N (68 lbf) Rocket Engine Assembly





Design Characteristics

- Propellant…………………………………………… Hydrazine
- Catalyst…………………………………… S-405/LCH-202
- Thrust/Steady State……….....…….. 307 - 182 N (69 - 41 lbf)
- Feed Pressure……………… 52.4 – 20.6 bar (760 - 300 psia)
- Chamber Pressure……………..8.4 – 2.6 bar (122 – 38 psia)
- Expansion Ratio…………………………………..... 21.5:1
- Flow Rate………… 98 – 31 g/sec (0.216 - 0.07 lbm/sec)
- Valve………………………………………………. Single Seat
- Valve Power……………... 34.8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power……. . 4.0 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 13.2 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………….. 1.38 kg (3.06 lbm)
  - Engine……………………………….. 1.16 kg (2.56 lbm)
  - Valve…………………………………. 0.22 kg (0.50 lbm)

Performance

- Specific Impulse…………………….229 - 223 sec (lbf-sec/lbm)
- Total Impulse………………… 102,691 N-sec (23,086 lbf-sec)
- Total Pulses………………………………………………. 4,412
- Min Impulse Bit………… 0.015 N-sec @ 5.9 bar & 16 ms ON
  ……………………….. (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing......................... 100 sec @ 111 N (25 lbf)

Status

- Flight Proven
- Currently in Production

Reference

- AIAA-2012-3817

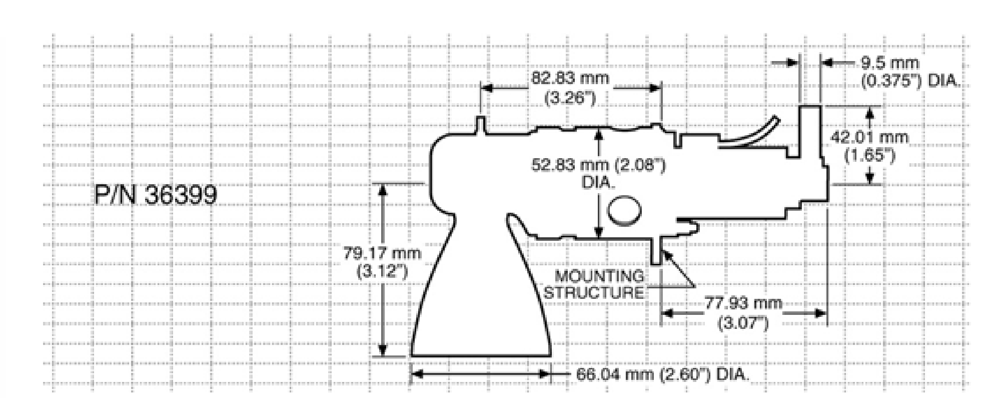
Note: ICD Available Upon Request

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MR-107V 300N (68 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant………………………………………… Hydrazine
- Catalyst…………………………………… S-405/LCH-202
- Thrust/Steady State……….....…… 220 - 67 N (49.5 - 15 lbf)
- Feed Pressure………………….. 26 – 5.5 bar (377 - 80 psia)
- Chamber Pressure……………..8.4 – 2.6 bar (122 – 38 psia)
- Expansion Ratio……………………………….... 21.5:1
- Flow Rate………… 98 – 31 g/sec (0.216 - 0.07 lbm/sec)
- Valve………………………………………… Single Seat
- Valve Power……………... 34.8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power……. . 4.0 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr…… 13.2 Watts Max @ 28 Vdc & 21°C
- Mass……………………………………. 1.01 kg (2.23 lbm)
  - Engine……………………………….. 0.67 kg (1.48 lbm)
  - Valve………………………………… 0.34 kg (0.75 lbm)
  - Heaters…………………………… 0.065 kg (0.14 lbm)

Performance

- Specific Impulse…………………….. 229 - 223 sec (lbf-sec/lbm)
- Total Impulse…………………. 362,303 N-sec (81,449 lbf-sec)
- Total Pulses………………………………………………. 10,161
- Min Impulse Bit………… 0.015 N-sec @ 5.9 bar & 16 ms ON
  ………………………… (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing.......................... 100 sec @ 111 N (25 lbf)

Status

- Flight Proven
- Currently in Production

Reference

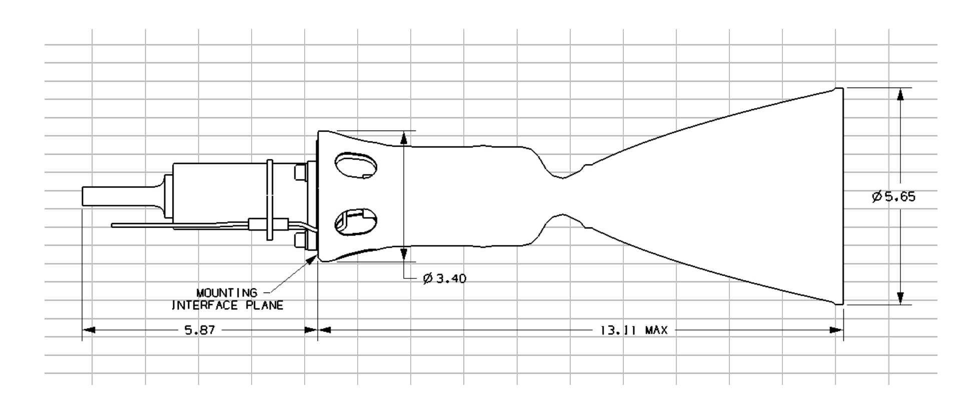
- AIAA-2012-3817

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(425) 885-5000 FAX (425) 882-5747

MR-104H 510N (115 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant……………………..……………………...Hydrazine
- Catalyst……………………..………………...S405/LCH-202
- Thrust/Steady State…….554.2 – 201.0 N (124.6 – 45.2 lbf)*
- Feed Pressure………………..28.9 – 6.9 bar (420 – 100psia)
- Chamber Pressure……………10.7 – 3.9 bar (155 – 56 psia)
- Expansion Ratio……………………………………………54:1
- Flow Rate…………249.5 – 90.8g/sec (0.55 – 0.20 lbm/sec)
- Valve………………………..……………………….Dual Seat
- Valve Power……………………..…….52 Watts @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr………..8.1 Watts/el @ 28 Vdc & 21°C
- Weight……………………………..……....2.40 kg (5.3 lbm)
  - Engine……………………………………1.40 kg (3.1 lbm)
  - Valve……………………………………..1.00 kg (2.2 lbm)

- **Performance**
- Specific Impulse……………….....237 – 223 sec (lbf-sec/lbm)
- Total Impulse………………..854,000 N-sec (192,000 lbf-sec)
- Total Pulses…………………………………………….6,520
- Minimum Impulse Bit………8.23 N-sec @ 24 bar & 22 ms ON
  ……………………..(1.85 lbf-sec @ 350 psia & 22ms ON)
- Steady State Firing…………………..2,011 sec – Single Firing
  ………..……………………….…2,654 sec – Cumulative

Status

- Flight Proven
- Currently in Production

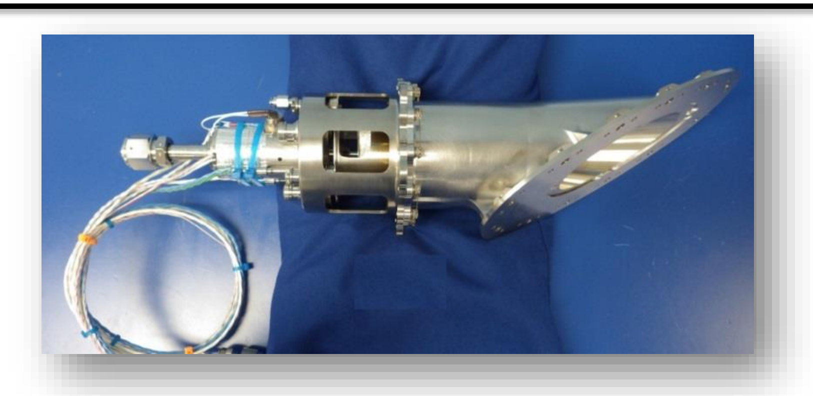
**Note: Thrust levels up to 200lbf have been demonstrated.*

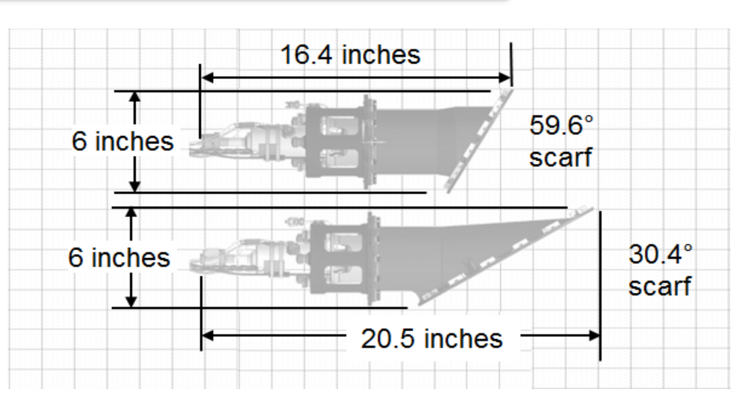
Photo: optional right angle thruster shown with 24:1 expansion ratio nozzle

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MR-104J 440N (100 lbf) Rocket Engine Assembly







Design Characteristics

- Propellant……………………….…………………...Hydrazine
- Catalyst…………………………………………...S405/LCH-202
- Thrust/Steady State………………….614 – 440 N (138– 99 lbf)**
- Feed Pressure……………….……28.2 – 20 bar (410 – 290psia)
- Chamber Pressure……………..…..12.4 – 8.5 bar (180– 124 psia)
- Expansion Ratio……………………………………..….……..7:1
- Flow Rate……………284.4 –195.0 g/sec (0.627 – 0.43 lbm/sec)
- Minimum Electrical Pulse width…………………………40 msec
- Valve…………………………………………………Dual Seat
- Max Valve Heater Power………………….….…6 Watts @ 37 Vdc
- Max Cat. Bed Heater Pwr………………...26 Watts/el @ 34 Vdc
- Max Valve Pwr……………………………56 Watts/coil@ 28 Vdc
- Weight (-301)…………………………….....   6.44 kg (14.2lbm)
  - Valve………………………………………..   1.00 kg (2.2 lbm)

**Note thrust levels up to 200lbf and down to 45 lbf have been demonstrated.*

Key Capabilities

- Thermally isolated valve
- Full mechanical attachment for integration and replacement simplicity
- Integrated flow inhibitor to block re-entry gasses
- Patent pending nozzle brace - Hot shock capable
- Designed for reusability

Performance

- Vac Specific Impulse (MR-104J)…...223 – 215 sec (lbf-sec/lbm)
- Total Impulse(MR-014G)……...912,000 N-sec (205,000 lbf-sec)
- Total Pulses(MR-104G)……………………………………6,600
- Steady State Firing (MR-104D)…..…..2,011 sec – Single Firing
  ……….………………………….……..…..2,654 sec – Cumulative

Status

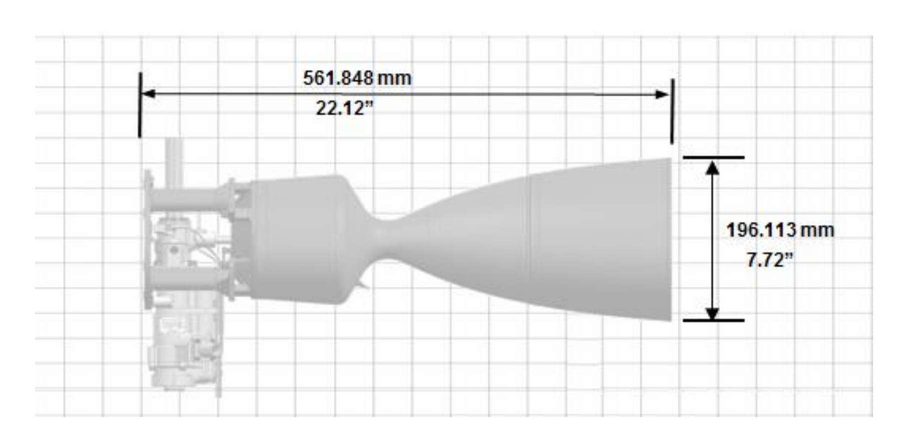
- Qualified; First Flight 2019
- Currently in Production

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(425) 885-5000 FAX (425) 882-5747

MR-80B 3,100N (700 lbf) Throttling Rocket Engine Assembly







Design Characteristics

- Propellant……………………………………………Hydrazine
- Catalyst………………………………………………..S-405
- Thrust/Steady State……......... …3603 - 31 N (810 - 7 lbf)
- Thrust step response…………………..80 msec for 90% step
- Feed Pressure…………………………….47. 2 bar (685 psia)
- Chamber Pressure…..……. …19.44 – 0.14 bar (282 - 2 psia)
- Expansion Ratio……………………………………..... 27.2:1
- Flow Rate……………..98 – 31 g/sec (3.64 - 0.0009 lbm/sec)
- Valve…………………………………………Cavitating Throttle
- Valve Power…………………..8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power……. 9.45 Watts Max @ 30 Vdc & 21°C
- Cat. Bed Heater Pwr…….. 6.3 Watts Max @ 30 Vdc & 21°C
- Mass………………………………………168 kg (18.76 lbm)
  - Engine………………………………..92 kg (15.26 lbm)
  - Valve………………………………1.59 kg (3.50 lbm)

Performance

- Specific Impulse…………………… 225 - 200 sec (lbf-sec/lbm)

	Dev. #1	Dev. #2	Dev. #3R	Qual.
Starts	8	8	12	10
Totals	292.1 kg	183.7 kg	451.3 kg	308.4 kg
Throughput	(644 lbm)	(405 lbm)	(995 lbm)	(680 lbm)
Total Firing Time	334 sec	418 sec	806 sec	560 sec
Longest Single Firing	76 sec	117 sec	137 sec	214 sec

Status

- Flight Proven
- Currently in Production

Reference

- 2007-AIAA-5481

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MRM-106F 40N (9.0-lbf) Rocket Engine Module





P/N 33010-303

3 Engine REM

217 mm (8.55")
228 mm (8.99")
100 mm (3.96")
MOUNTING FLANGE

Design Characteristics

- Propellant…………………..Monopropellant Hydrazine
- Catalyst………………………………...…LCH-207/202
- Thrust/Steady State (per rocket)………...40N (9.0 lbf)
- Chamber Pressure…………………..16 bar (237 psia)
- Expansion Radio…………………………………..61:1
- Flow Rate…………………..17.7 g/sec (0.039 lbm/sec)
- Valve…………………….. Single Seat, Non-sliding Fit
- Valve Power…20.1 Watts Nominal @ 28 Vdc & 21°C
- Mass………………………<2.23 kg (4.9 Ibm) per REM
- No Catalyst Bed Heaters or Valve Heaters
- 22 Pin Electrical Connector

Performance

- Specific Impulse…………..…………231 sec (lbf-sec/lbm)
- Total Impulse………...…136,000 N-sec (30,618 lbf-sec)
- Total Pulses………………………………..…………..…1,570
- Minimum Impulse Bit…2.62 N-sec @ 31 bar & 20 ms ON
  ……………………(.0.59 lbf-sec @450 psia & 60 ms ON)
- Steady State Firing……………….1,000 sec Single Firing
  ……………………………………… 2,991 sec –Cumulative

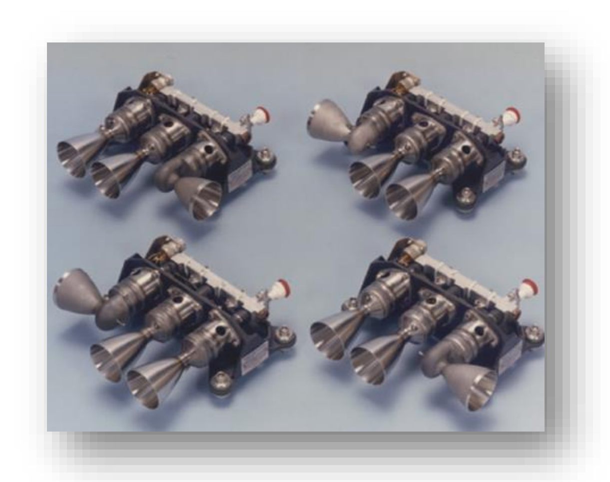
Status

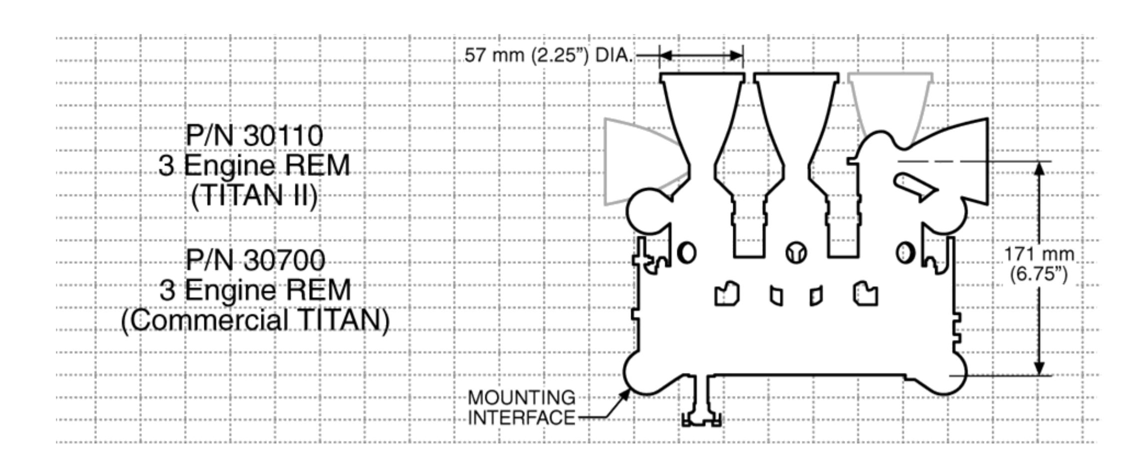
- Flight Proven
- Currently in Production

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MRM- 122 130N (30-lbf) Rocket Engine Module







Design Characteristics

- Propellant……………………………………...…….Hydrazine
- Catalyst……………………………. …………………….LCH
- Thrust/Steady/ State…..………………..142 – 51N (32-11.5 lbf)
- Feed Pressure……………….29.6 – 6.9 bar (430 – 100 psia)
- Chamber Pressure…..…………..5.4 – 2.0 bar (79 – 29 psia)

  Expansion Ratio……….……........20.7:1 (Axial), 21.5:1 (Roll)
- Flow rate…………....63.5 – 24.0g/sec(0.14 – 0.053 lbm/sec)
- Valve…………………………………………..……..Single seat
- Valve Power…….……………...43 Watts Max @ 32 Vdc & 4°C
- No Catalyst Bed Heaters or Valve Heaters
- 19 Pin Electrical Connectors on REM
- Mass…… Axial: 0.66kg (1.46 lbm) / Lateral: 0.76kg (1.68lbm)

  Engine…Axial: 0.54 kg (1.20 lmb) / Lateral: 0.64 kg (1,42 lbm)

  Valve..…Axial: 0.12 kg (0.26 lbm) / Lateral: 0.26 kg (0.26 lmb)

Performance

- Specific Impulse… ……………..228 – 217 sec (lbf-sec/lbm)
- Total Impulse…………………332,000N-sec (74715 lbf-sec)
- Total pulses…………………………………………….7,005
- Minimum impulse Bit……..1.20 N-sec @9.3 bar & 20ms ON

  ……………………..…(0.27 lbf-sec @135 psia & 20 ms ON)
- Steady State Firing………………...2,137 sec – Single Firing

  ……………………………………….2,684 sec- Cumulative

Status

- Flight Proven
- Currently in Production

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Bipropellant Propulsion



AR has delivered >2,500 bipropellant engines





HiPAT™ Dual Mode 100 lbf



HiPAT™ 100 lbf



R-4D 110 lbf



R-42 200 lbf



R-40B 900 lbf



R-6F 5 lbf



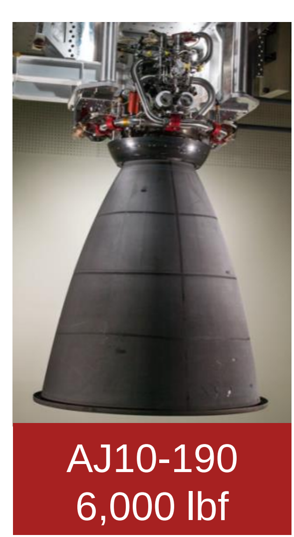
R-1E 25 lbf



R-1E 25 lbf Shuttle Vernier



AJ10-220 14 lbf



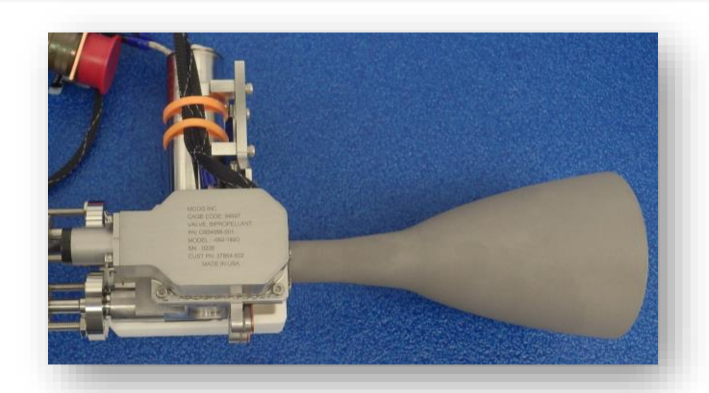
AJ10-190 6,000 lbf

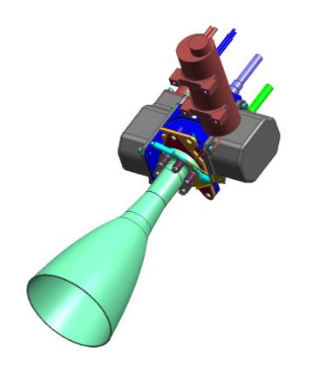
Bipropellant rocket engines range from 5 lbf to 6000 lbf

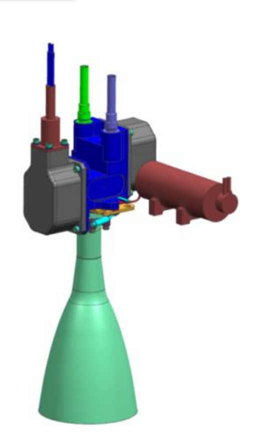
11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

AJ10-220 62.3 N (14.0 lbf) Reaction Control Thruster









Design Characteristics

- Propellant . . . . .MMH/NTO (MON-3)
- Nominal Thrust (steady state) . . . . .62.3 N (14.0 lbf)
- Thrust Range (steady state)* . . . . .59.2–65.4 N (13.3-14.7 lbf)
- Chamber Pressure* . . . . 6.89 bar (100 psia)
- Inlet Pressure* . . . . 15.2 bar (220 psia)
- Inlet Pressure Range . . . . .25.5 – 9.99 bar (370 – 145 psia)
- Valve, Power . . . . .Moog, 38 W @ 28 VDC
- Expansion Ratio 75:1
- Nominal Flow Rate .22.3 g/s (0.049 lbm/s)
- Nominal Mixture Ratio (O/F) 1.65
- Mixture Ratio Range (O/F) . . . . .1.50 -1.80
- Mass . . . . 1.95 kg (4.3 lbm)

Performance

- Specific Impulse @ 220 psia, 70°F and MR=1.65……………… ……………………..285 s (Steady firing) / 268 s (Pulse Mode)
- Total Impulse Qualified ………...685,000 N-s (154,000 lbf-s)
- Minimum Impulse Bit . . . . 0.898 N-s (0.202 lbf-s)
- Demonstrated Steady State Firing Duration .. . . .300 s
- Total Number of Pulses Qualified . . . . .65,000+ starts

Status

- Flight Proven
- Currently in Production

Dimensional Envelope

- 19.0 cm (7.5 in) long, 7.30 cm (2.9 in) diameter

References

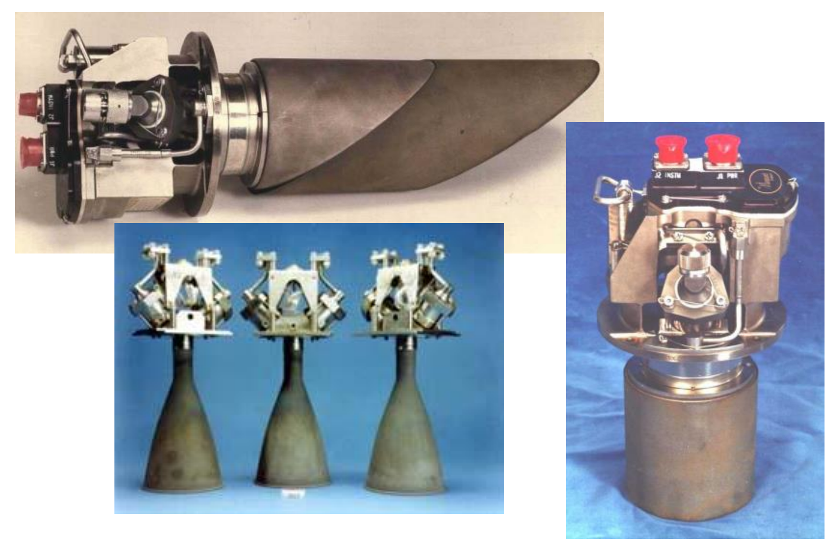
- 1993-AIAA-2218

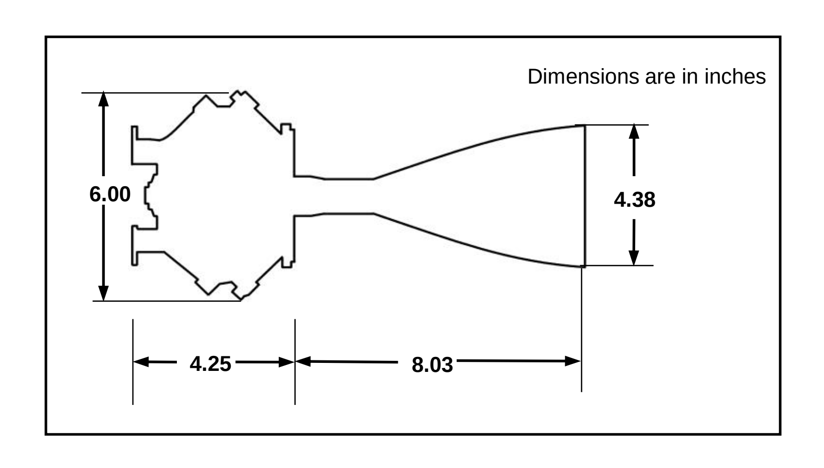
** Standard Inlet Conditions*

11411 139th Place NE • Redmond, WA 98052
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R-1E 110N (25 lbf) Bipropellant Rocket Engine







Design Characteristics

- Propellant….. . . . . MMH/NTO(MON-3)
- Thrust/Steady State . . .. 111 N (25 lbf)
- Inlet Pressure Range . . . . 27.6-6.9 bar (400-100 psia)
- Chamber Pressure*. . . . . 7.3 bar (106 psia)
- Expansion Ratio………... . . . . 100:1
- Flowrate* . . . . 40.4 g/sec (0.089 lbm/sec)
- Valve. . . . . Aerojet Solenoid, Single Coil, Single Seat
- Valve Power . . . . 36 Watts @ 28 Vdc
- Mass. . . . .…. 2 kg (4.4 lbm)

Performance

- Specific Impulse*. . . . . 280 sec (lbf-sec/lbm)
- Total Impulse. ….11,120,000 N-sec (2,500,000 lbf-sec)
- Total Pulses 330,000
- Minimum Impulse Bit . . . . .0.89 N-sec (0.2 lbf-sec)
- Steady State Firing (sec). .. . . No Limitations

Status

- Flight Proven
- Currently in Production

Reference

- AIAA - 1990 - 1837

** At rated thrust*

11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

R-4D-11 490 N (110 lbf) Bipropellant Rocket Engine







DIMENSIONS ARE IN INCHES

44:1 = 6.01
164:1 = 11.0
300:1 = 14.84

2.5

44:1 = 9.97
164:1 = 19.32
300:1 = 26.5

Design Characteristics

- Propellant . . . . MMH/NTO (MON-3)
- Nominal Thrust (steady state) . . . . .490 N (110 lbf)
- Thrust Range (steady state) . . . . . .378 – 511 N (85-115 lbf)
- Chamber Pressure* . . . . .7.45 bar (108 psia)
- Inlet Pressure* . . . . >14 bar (>205 psia)
- Inlet Pressure Range . . . . . . .4.1 – 29.3 bar (60 – 425 psia)
- Valve . . . . Aerojet Rocketdyne, Single Coil, Single Seat
- Expansion Ratio 164:1, 300:1
- Nominal Mixture Ratio (O/F) 1.65
- Mixture Ratio Range (O/F) . . . . .1.17 – 2.13
- Mass …..164:1 = 3.76 kg (8.3 lbm), 300:1 = 4.31 kg (9.5 lbm)

Performance

- Specific Impulse @ 70°F and MR = 1.65 . . . .

  ………..... . . .. .164:1 = 311 sec (lbf-sec/lbm)

  . . . . .300:1 = 315.5 sec (lbf-sec/lbm)
- Total Impulse Demonstrated……20,016,000 N-sec (4,500,000 lbf-sec)
- Minimum Impulse Bit . . . . .15.6 N-sec (3.5 lbf-sec)
- Demonstrated Steady State Firing Duration….. . . . . 12,000 s
- Total Number of Pulses Qualified . . . . .31,950 starts┼

  ……………………………………C-103/Ti 300:1 = 85 thermal cycles┼

  …………………………………… C-103 164:1 = 245 thermal cycles┼

Status

- Flight Proven
- Currently in Production

References

- AIAA-2004-3694, AIAA-1980-1294, AIAA-1979-1331

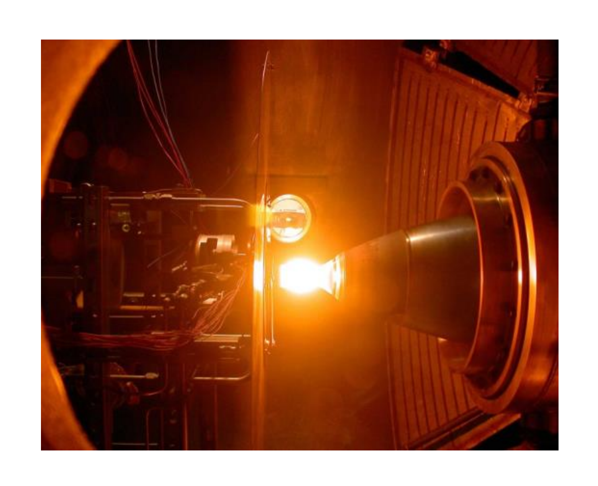
┼ Performed on different engines.

** At nominal thrust*

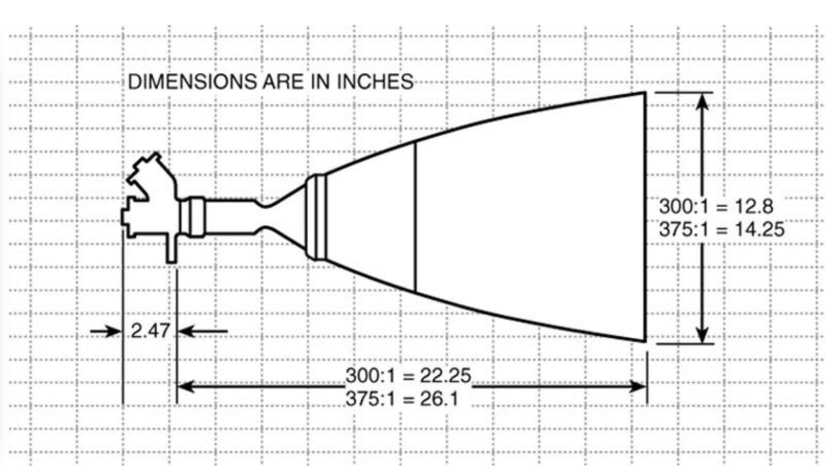
11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

R-4D-15 HiPAT™ 445 N (100 lbf) High Performance Rocket Engine









Design Characteristics

- Propellant . . . . MMH/NTO (MON-3)
- Nominal Thrust (steady state) . . . .445 N (100 lbf)
- Thrust Range (steady state) . . . . . . .378 – 511 N (85-115 lbf)
- Chamber Pressure* . . . . .9.44 bar (137 psia)
- Inlet Pressure* . . . . >14 bar (>205 psia)
- Inlet Pressure Range . . . . 27.6 - 6.9 bar (400 – 100 psia)
- Valve . . . . Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio . . . . .300:1 or 375:1
- Nominal Mixture Ratio (O/F) 1.65
- Mixture Ratio Range (O/F) . . . . .1.50 -1.80
- Mass . . . . .300:1, 5.2 kg (11.5 lbm) / 375:1, 5.44 kg (12.0 lbm)

** At nominal Thrust*

Performance

- 375:1 Specific Impulse @ 70°F and MR = 1.65 . . . .
  . . . . .320.6 s (typical for 60 s run)
  . . . . 322.2 s (typical for 1200+ s run)
- Total Impulse Qualified……13,019,945 N-s (2,927,000 lbf-s)
- Minimum Impulse Bit . . . . 35.6 N-s (8 lbf-s)
- Demonstrated Steady State Firing Duration ………7,200 sec
- Total Number of Pulses Qualified . . . . . ………… ..391 starts
  ………………………………………………..85+ thermal cycles

Status

- Flight Proven
- Currently in Production

References

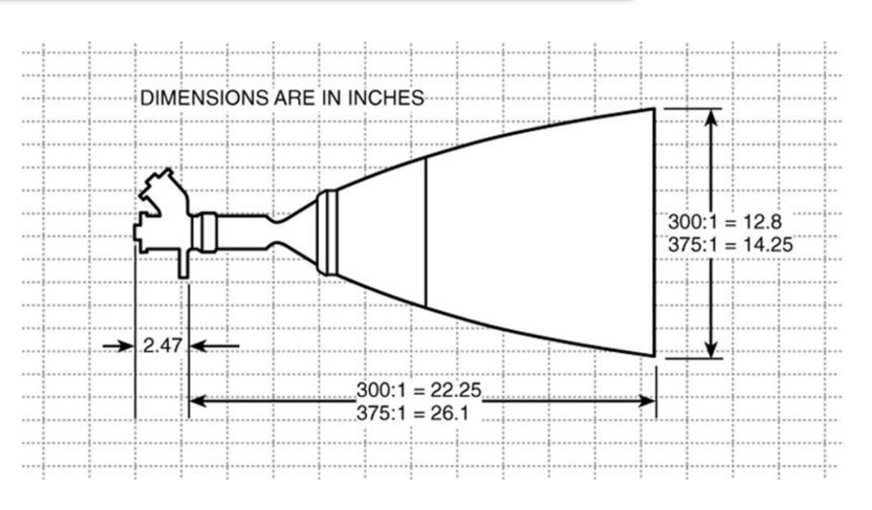
- AIAA-2001-3253, AIAA-2000-3161

11411 139th Place NE • Redmond, WA 98052
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R-4D-15 HiPAT™ 445 N (100 lbf) Dual Mode High Performance Rocket Engine







Design Characteristics

- Propellant . . . . .Hydrazine/NTO (MON-3)
- Nominal Thrust (steady state) . . . . 445 N (100 lbf)
- Thrust Range (steady state) . . . . .329 – 556 N (70-125 lbf)
- Chamber Pressure* . . . . .9.4 bar (137 psia)
- Inlet Pressure* . . . . >16.2 bar (235 psia)
- Inlet Pressure Range . . . . .21.4 – 15.2 bar (310 – 220 psia)
- Valve . . . . .Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio . . . . 300:1 or 375:1
- Nominal Mixture Ratio (O/F) 1.0
- Mixture Ratio Range (O/F) . . . . 0.70 – 1.33
- Mass . . . . . 300:1= 5.2 kg (11.5 lbm), 375:1 = 5.44 kg (12.0 lbm)

Performance

- Specific Impulse @ 70°F and MR = 1.0. . . . .
  . . . . 300:1= 326 sec, 375:1 = 329 sec
- Total Impulse Qualified……………………………………..
  ……………………..> 9.55 X10^{6} N-sec (2.15 X 10^{6} lbf-sec)
- Minimum Impulse Bit . . . . 35.6 N-s (8 lbf-s)
- Demonstrated Steady State Firing Duration …….1,800 sec
- Total Number of Pulses Qualified . . . . 672 starts

. . . . 345 thermal cycles

Status

- Qualified
- Currently in Production

References

- AIAA-2003-4775

** At nominal Thrust*

11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

R-42 890N (200 lbf) Bipropellant Rocket Engine





Dimensions are in inches

15.34

6.0

25.00

Series Valve Configuration Shown

Design Characteristics

- Propellant. . . . . MMH/NTO(MON-3)
- Thrust/Steady State. . . . . 890 N (200 lbf)
- Inlet Pressure Range . . . . 29.3-6.9 bar (425-100 psia)
- Chamber Pressure*. 7.1 bar (103 psia)
- Expansion Ratio. 160:1
- Flowrate*.. . . . . 300 g/sec (0.66 lbm/sec)
- Valve . . . . Aerojet Rocketdyne Single or Dual Seat
- Valve Power……………………………………………Various

  …………...…….(46 Watts @ 28 Vdc Typical for Single Seat)
- Mass. . . . . .4.53 kg (10.0 lbm)

Performance

- Specific Impulse* . . . . 305 sec (lbf-sec/lbm)
- Total Impulse . . . . 24,271,000 N-sec (5,456,700 lbf-sec)
- Total Starts 150
- Minimum Impulse Bit . . . . 44.48 N-sec (10.0 lbf-sec)
- Steady State Firing Cumulative . . . . 27,000 sec
- Steady State Firing (Single Firing) . . . . 3,940 sec

Status

- Flight Proven
- Currently in Production

Reference

- AIAA - 1990 - 2055

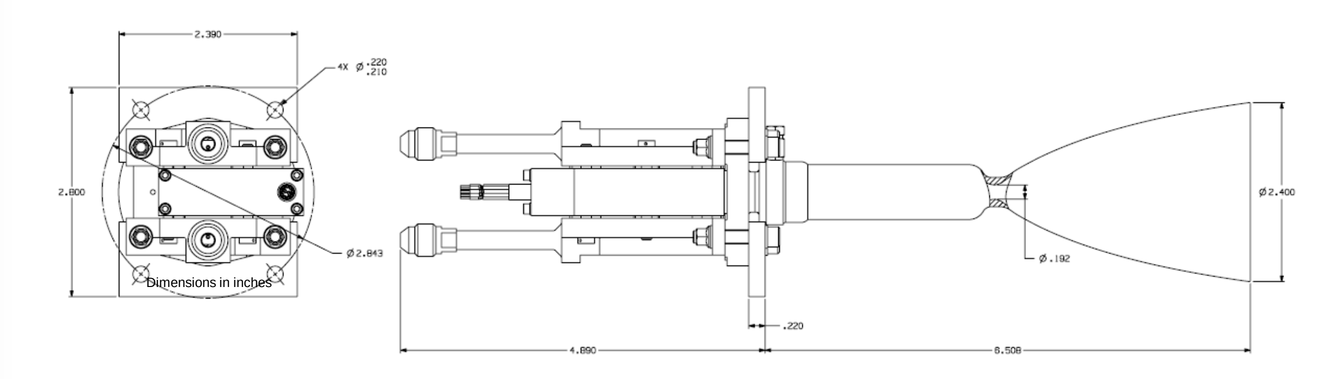
**At nominal conditions*

11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

R-6F 22N (5lbf) Bipropellant Rocket Engine







Design Characteristics

- Propellant . . . . MMH/NTO (MON-3)
- Thrust/Steady State . . . . .22 N (5 lbf)
- Operating Thrust Range . . . . . . 13.3 to 27.8 N (3.0 to 6.25 lbf)
- Mixture Ratio/Steady State 1.61
- Operating Mixture Ratio Range . . . . 1.0 to 2.0
- Expansion Ratio 150:1
- Nominal Flow Rate . . . . .7.44 g/sec (0.00164 lbm/sec)
- Inlet Pressure. . . . . 6.9 to 20.79 bar (100 to 300 psia)
- Valve . . . . .Bipropellant duel seat solenoid with upstream latching feature
- Valve Power . . . . .11 watts @ 28 Vdc)
- Mass. . . . . 0.965 kg (2.1 lbm)

Performance

- Specific Impulse .305 lbf-sec/lbm
- Total Impulse . . . . >89,700 N-sec (20,175 lbf-sec)
- Total pulses . . . .>19,881
- Minimum Impulse Bit . . . . 0.53 N-sec (0.12 lbf-sec)
- Steady State Firing . . . . .0.010 sec to Unlimited

Status

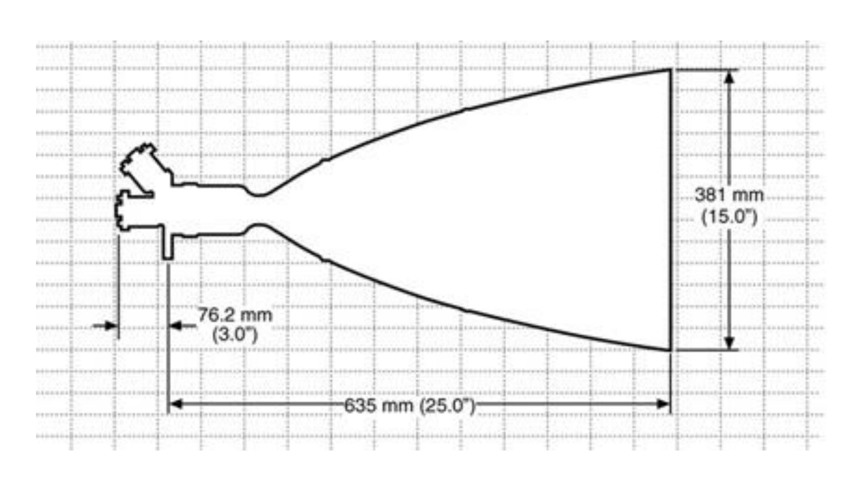
- Ready for flight qualification
- Not in Production

11411 139th Place NE • Redmond, WA 98052
(425) 885-5000 FAX (425) 882-5747

R-42DM 890N (200 lbf) Dual Mode High Performance Rocket Engine







Design Characteristics

- Propellant. . . . . Hydrazine/NTO(MON-3)
- Thrust/Steady State*. . . . . .890 N (200 lbf)
- Inlet Pressure Range . . . . 31.0-5.5 bar (450-80 psia)
- Chamber Pressure*. . . . . 9.6 bar (140 psia)
- Expansion Ratio……………………………..………………………..200:1
- Oxidizer / Fuel Ratio…………………………..0.8 – 1.30 (1.0 nominal)
- Flowrate*……………………………………….277 g/sec (0.61 lbm/sec)
- Valve…………………………Aerojet Rocketdyne Single or Dual Seat
- Valve Power…..Various (45 Watts @ 28 Vdc Typical for Single Seat)
- Mass…………………………..with single seat valves 7.3 kg (16.0 lbm)

Performance

- Specific Impulse* . . . . 327 sec (lbf-sec/lbm)
- Total Impulse……..>20,000,000 N-sec (4,500,000 lbf-sec)
- Total Starts . . . .…… ..………………... . . >60
- Minimum Impulse Bit………..... 44.48 N-sec (10.0 lbf-sec)
- Steady State Firing Cumulative . . . . 6,400 sec
- Steady State Firing (Single Firing) . . . . 1,000 sec

Status

- Ready for flight qualification
- Not in Production

At nominal conditions

11411 139th Place NE • Redmond, WA 98052
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AMBR 556 N (125 lbf) Dual Mode High Performance Rocket Engine





Center of Gravity
Throat C/L
Y
X
14.6 [371]
1.3 [33]
.4 [10]
2.5 [63]
26 [660]
Dimensions are shown in inches.
Dimensions in brackets are millimeters.

Design Characteristics

- Propellant . . . . .Hydrazine/NTO(MON-3)
- Nominal Thrust (steady state) . . . . .489 – 556 N (110 – 125 lbf)
- Thrust Range (steady state) . . . . .325 – 645 N (73 – 145 lbf)
- Chamber Pressure* . . . . 10.3 – 11.7 bar (150 – 170 psia)
- Inlet Pressure* . . . . >14 bar (>205 psia)
- Valve . . . . Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio 400:1
- Nominal Mixture Ratio (O/F) . . . . .1.0 – 1.3
- Mixture Ratio Range (O/F) . . . . .0.62 – 1.96
- Mass . . . . .4.9 kg (10.8 lbm)

** At nominal Thrust*

Performance

- Specific Impulse @ 70°F and MR = 1.0 . . . . . .329 sec (lbf-sec/lbm)
- Total Impulse. . . . . 5,792,919 N-sec (1,302,300 lbf-sec)
- Demonstrated Steady State Firing Duration . . . . .2,700 sec
- Total Number of Starts Demonstrated . . . . .88 total starts

Status

- Ready for final flight design/analysis, and qualification
- Not in Production

References

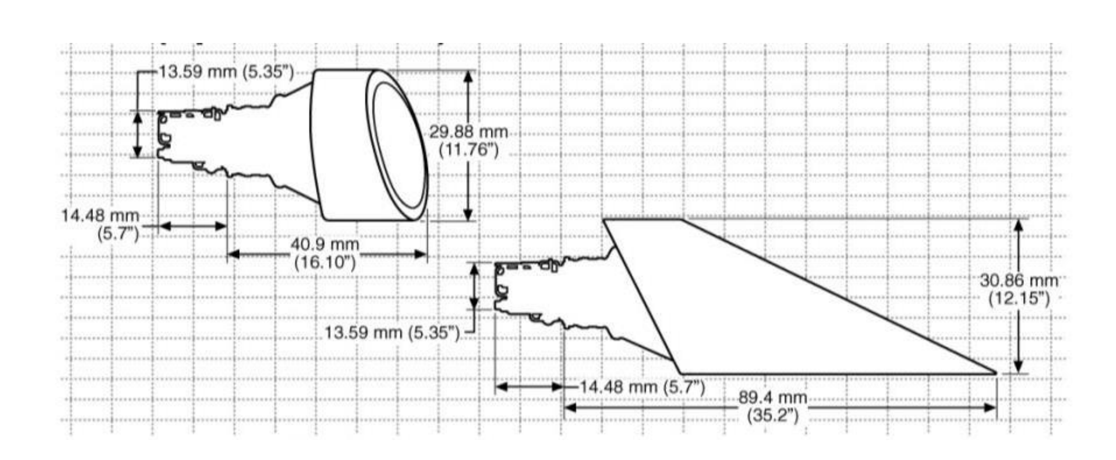
- AIAA-2007-032, AIAA-2008-4844, AIAA-2010-6883

11411 139th Place NE • Redmond, WA 98052
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R-40 3,870N (870 lbf) Bipropellant Rocket Engine







Design Characteristics

- Propellant. . . . . MMH/NTO(MON-3)
- Thrust/Steady State*. . . . . 3,870 N (870 lbf)
- Inlet Pressure Range . . . . 27.6 – 10.3 bar (400 - 150 psia)
- Chamber Pressure*. . . . . 9.9 bar (150 psia)
- Expansion Ratio. 22:1
- Flowrate*.. . . . . .1,400 g/sec (3.07 lbm/sec)
- Valve . . . . Aerojet Rocketdyne Single Seat
- Valve Power . . . . .70 Watts @ 28 Vdc
- Mass** . . . . .10.5 kg (23.0 lbm)

**At rated thrust*

***Varies by configuration*

Performance

- Specific Impulse* . . . . 281 sec (lbf-sec/lbm)
- Total Impulse . . . . 92,073,600 N-sec (20,700,000 lbf-sec)
- Total Pulses 50,000
- Minimum Impulse Bit . . . . 111 N-sec (25.0 lbf-sec)
- Steady State Firing Cumulative. . . . . 23.,000 sec

Status

- Flight Proven
- Not in Production; Requires component obsolescence update

Reference

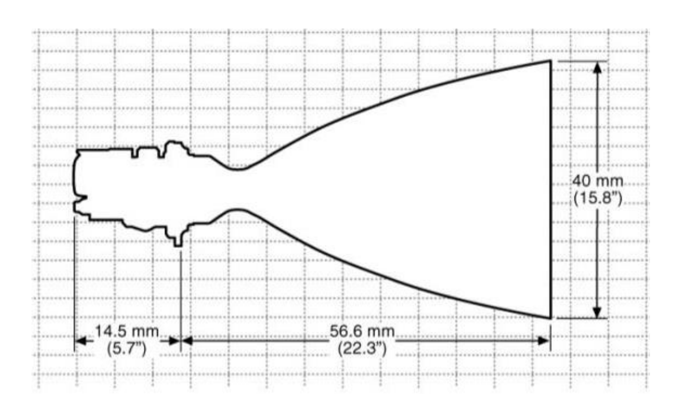
- AIAA-1985-1222
- AIAA-1980-1131
- AIAA-1980-1130
- AIAA-1979-1144
- AIAA-1978-1006
- AIAA-1975-1300
- AIAA-1974-1109
- AIAA-1970-0618

11411 139th Place NE • Redmond, WA 98052
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R-40B 4,000N (900 lbf) Bipropellant Rocket Engine







Design Characteristics

- Propellant. . . . . MMH/NTO(MON-3)
- Thrust/Steady State*. . . . . 4,000 N (900 lbf)
- Inlet Pressure Range . . . . 27.6 – 10.3 bar (400 - 150 psia)
- Chamber Pressure*. . . . . 10.34 bar (150 psia)
- Expansion Ratio. 60:1
- Flowrate*.. . . . . .1,400 g/sec (3.07 lbm/sec)
- Valve . . . . Aerojet Rocketdyne Single Seat
- Valve Power . . . . .70 Watts @ 28 Vdc
- Mass. . . . . .10.5 kg (23.0 lbm)

**At rated thrust*

Performance

- Specific Impulse* . . . . 293 sec (lbf-sec/lbm)
- Total Impulse . . . . 92,073,600 N-sec (20,700,000 lbf-sec)
- Total Pulses 50,000
- Minimum Impulse Bit . . . . 111 N-sec (25.0 lbf-sec)
- Steady State Firing Cumulative. . . . . 23,000 sec

Status

- Flight Proven
- Not in Production; Requires component obsolescence update

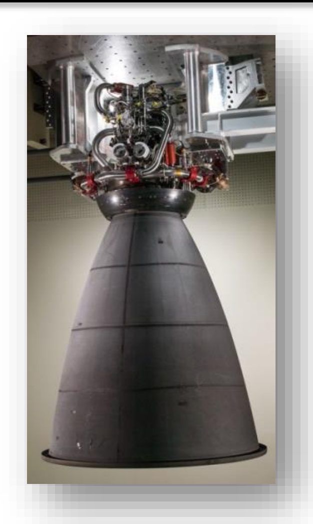
Reference

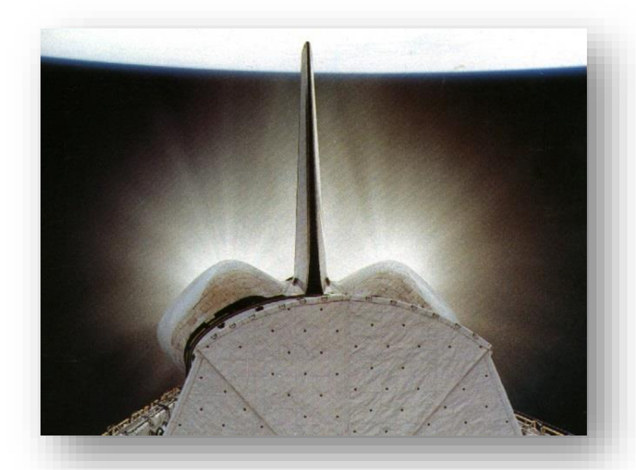
- IAF-1987-0283

11411 139th Place NE • Redmond, WA 98052
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AJ10-190 Space Shuttle OMS Rocket Engine







Design Characteristics

- Propellant…………………………………………….MMH/NTO(MON-3)
- Thrust/Steady State*……………………………………….N (6,000 lbf)
- Inlet Pressure Range ………………………………16.6 bar (240 psia)
- Chamber Pressure*……………………………………….bar (125 psia)
- Expansion Ratio………………………………….…………………55:1
- Flowrate……………………………………..8.61 kg/sec (19.0 lbm/sec)
- Valve………Aerojet Rocketdyne Pneumatic Procured Solenoid Pilot
- Valve Power (all coils energized) ………………125 Watts @ 28 Vdc
- Mass……………………………………………………118kg (260 lbm)
- Engine Length 77 in. / Engine Dia. 46 in.

**At rated thrust*

Performance

- Specific Impulse* ………………316 sec (lbf-sec/lbm)
- Gimbal ……………………………………….…….± 7 °
- Total Impulse.…1,440 MN-sec (324,000,000 lbf-sec)
- Total Starts ………………………………………1,000
- Steady State Firing Cumulative……….….54,000 sec

Status

- Flight Proven
- Not in Production

Reference

- AIAA 2014-3882

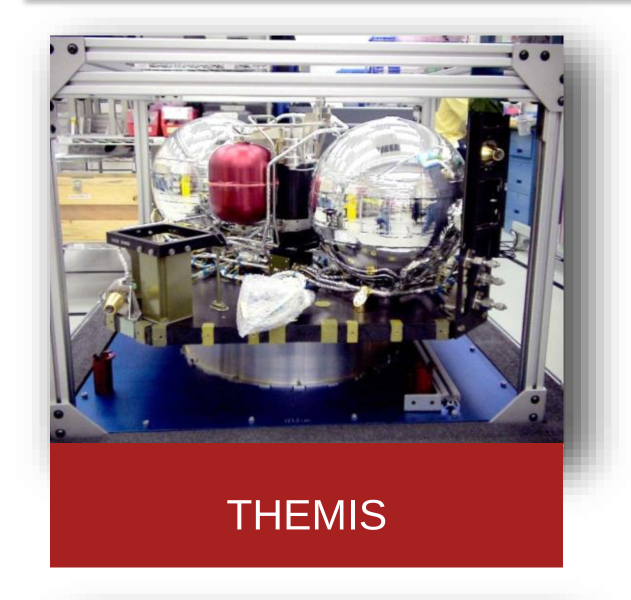
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Chemical Propulsion Systems



AR has delivered 250 flight propulsion systems





THEMIS



STEREO



RBSP



New Horizons



GPSIIF

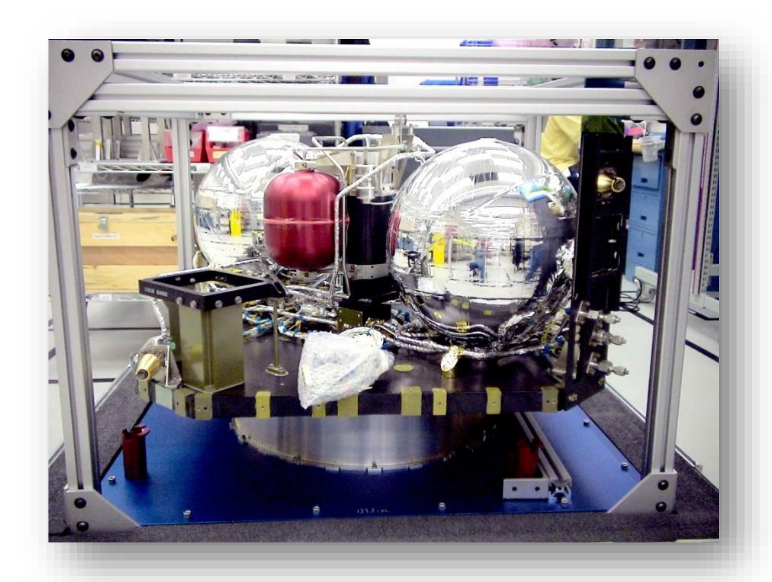


GPIM

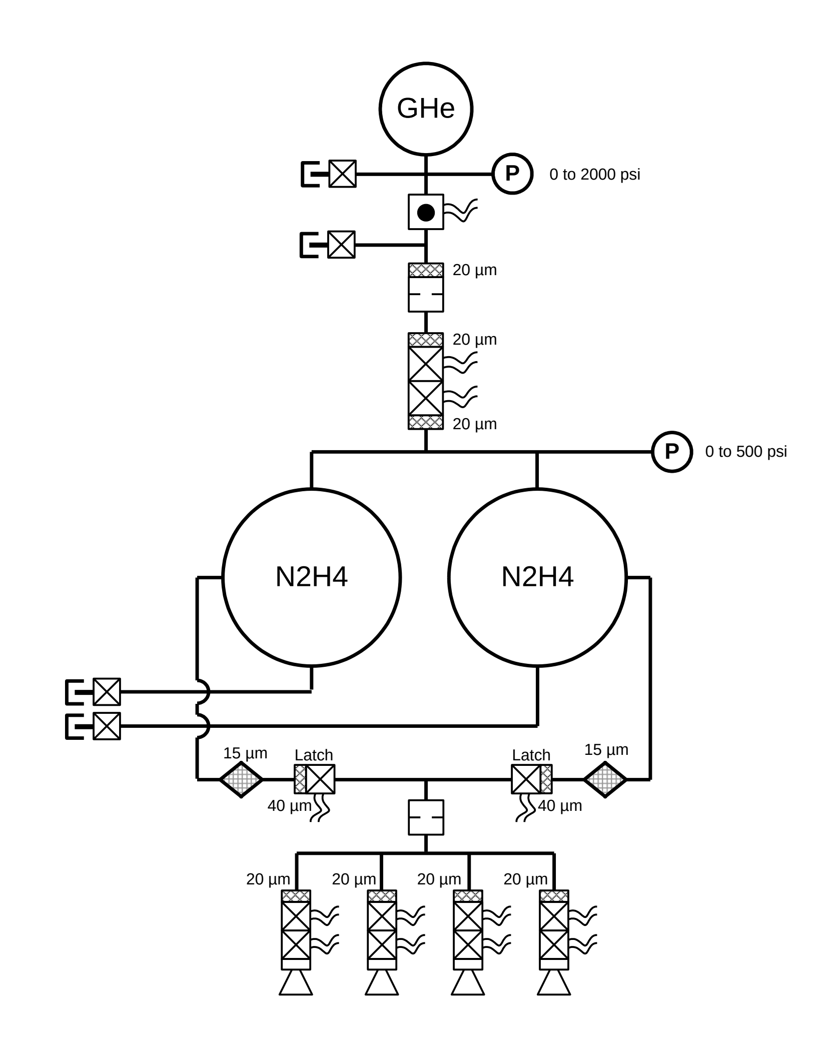
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THEMIS





- THEMIS: Time History of Events and Macroscale Interactions During Substorms
- NASA MIDEX Mission, Launched February 17, 2007
- Number of Systems: 5
- Propellant Load: 109 lbm (49.5 kg) Hydrazine
- 400-50 psia (27.6-3.5 bar) Blowdown Operation with Single Repressurization Event from 1700 psia (117 Bar) Pressurant Subsystem
- 4 MR-111C 1-lbf (4.5 N) Thrusters
- Used for Delta-V and Orbit Maintenance
- Aerojet Designed and Integrated System on Customer-Supplied Structure
- Reference: AIAA-2006-5217

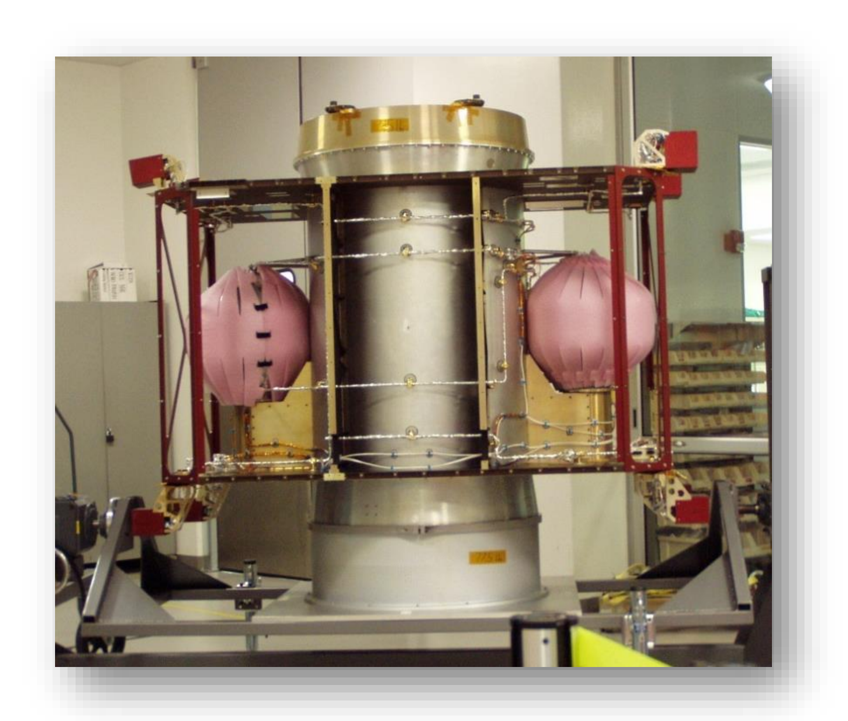


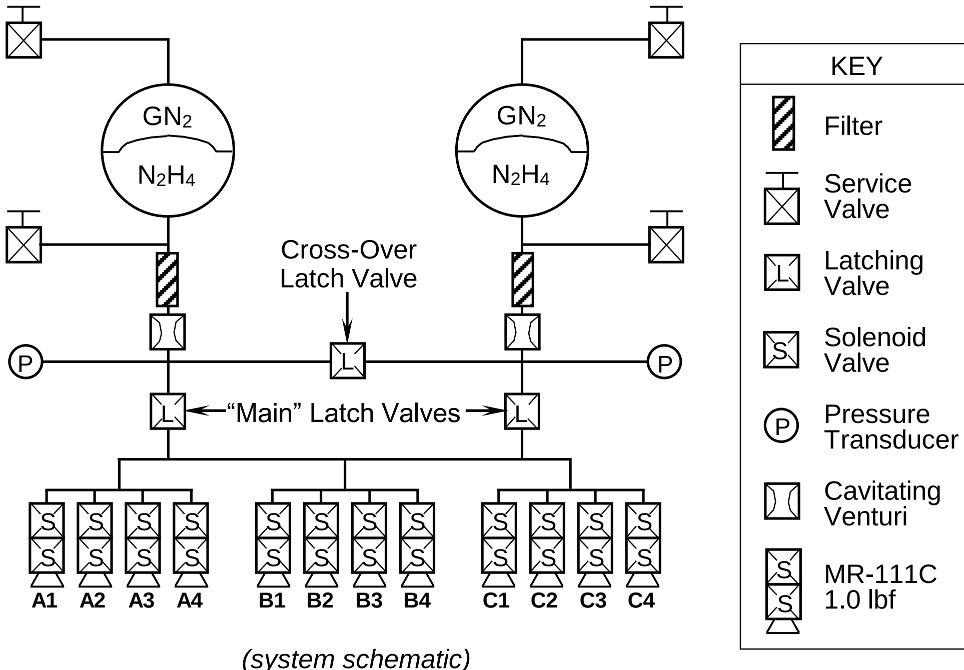
(System Schematic)

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STEREO





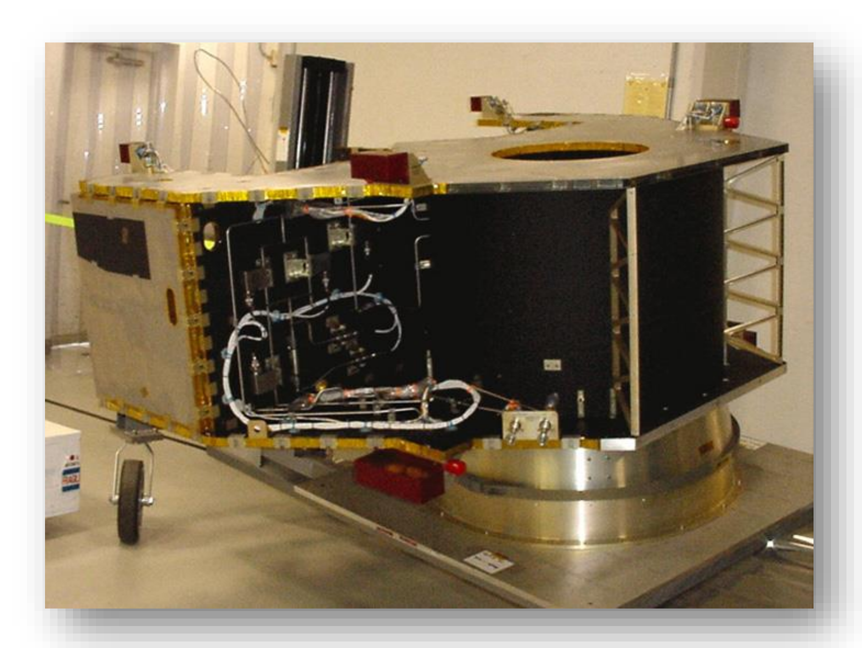


(system schematic)

- STEREO: Solar-TErrestrial RElations Observatory
- NASA Earth-Sun Science Mission
- Launched: October 26, 2006
- Systems Delivered to JHU/APL: 2
- Propellant Load: 135 lbm (61 kg) Hydrazine Each
- 320-110 psia (22.1-7.6 bar) Blowdown Operation
- 12 MR-111C 1.0-lbf (4 N) Thrusters
- Designed for Attitude Control and Course Correction
- Aerojet Rocketdyne Designed and Integrated System on Customer-Supplied Structure

New Horizons





- Mission to Pluto
- Launched: January 19, 2006
- Systems Delivered to JHU/APL: 1
- Propellant Load:143 lbm (65 kg) Hydrazine
- 420-75 psia (28.9-5.2 bar) Blowdown Operation
- 12 MR-103H 0.2-lbf (1N) Thrusters
- 4 MR-111C 1-lbf (5N) Thrusters
- Designed for Attitude Control and Course Correction
- Aerojet Designed and Integrated System on Customer-Supplied Structure
- Reference: IAC-2004-S.1.09

KEY

- MR-111C 1 lbf Rocket Engine Assy.
- MR-103H 0.2 lbf Rocket Engine Assy.
- Service Valve
- Latching Valve
- Solenoid Valve
- Pressure Transducer
- Flow Control Orifice
- Propellant Filter
- Ti/CRES Transition Joint

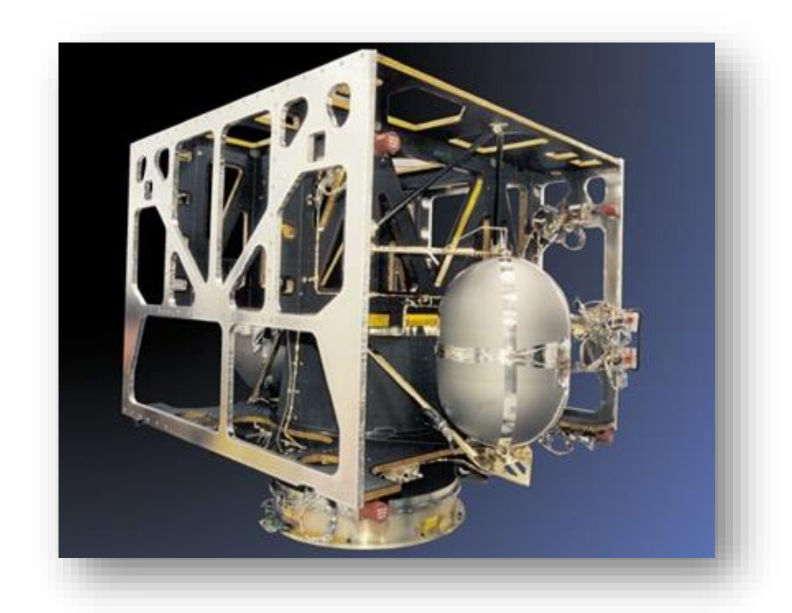
GN_2 / N_2H_4 — SV1, SV2, Service Panel — P1, P2 — LV1, LV4, LV5, LV6, LV3, LV2 — REM A (A1, A2, A3) — REM B (B1, B2, B3) — REM D (D1, D2, D3, D4) — REM C (C1, C2, C3, C4) — F1, F2

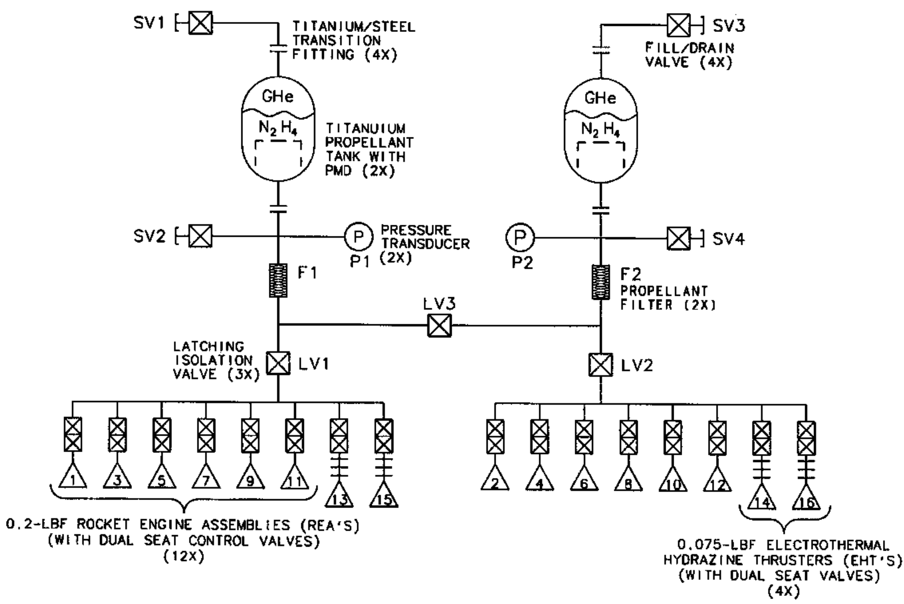
(System Schematic)

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BSAT-2





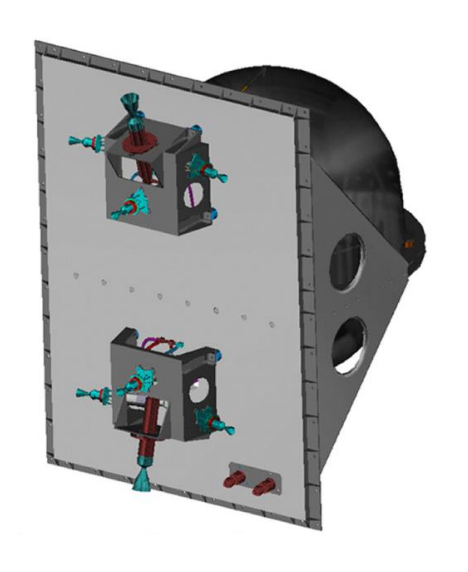


- Systems Flown: 3
- Propellant Load: 464 lbm (210 kg) Hydrazine Total in 2 Tanks
- 400-100 psia (27.5-6.9 bar) Blowdown Operation
- 12 MR-103G 0.2-lbf (1 N) Thrusters
- 4 MR-501B Electrothermal Hydrazine Thrusters (EHTs)
- Used for Orbit Raising and Attitude Control (GEO Spacecraft)
- Aerojet Integrated System on Customer-Supplied Structure

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GPS IIF Modernization Program Propulsion System Design Summary





MODULE 1
FILL / DRAIN VALVE
PROPELLANT TANK
FILL / DRAIN VALVE
#1A PRESSURE TRANSDUCER
#2A PRESSURE TRANSDUCER
FUEL FILTER
LATCH VALVE

MODULE 2
FILL / DRAIN VALVE
PROPELLANT TANK
FILL / DRAIN VALVE
#1B PRESSURE TRANSDUCER
#2B PRESSURE TRANSDUCER
FUEL FILTER
LATCH VALVE

4N (1lbf) THRUSTERS
22N (5 lbf) THRUSTER
REM 1A

4N (1lbf) THRUSTERS
22N (5 lbf) THRUSTER
REM 2A

4N (1lbf) THRUSTERS
22N (5 lbf) THRUSTER
REM 1B

4N (1lbf) THRUSTERS
22N (5 lbf) THRUSTER
REM 2B

Performance Parameters

- Propellant Mass…118 – 145kg (260 – 320 lbm)
- Total Impulse…249,000 N-S (56,000 lbf-sec)
- Pressurant Mass… 1.8 kg (4lbm)
- Pressure BOL/EOL…27.5/6.5 – 11.4 bar (400/95 – 165 psia)
- Blowdown Ratio…4:1

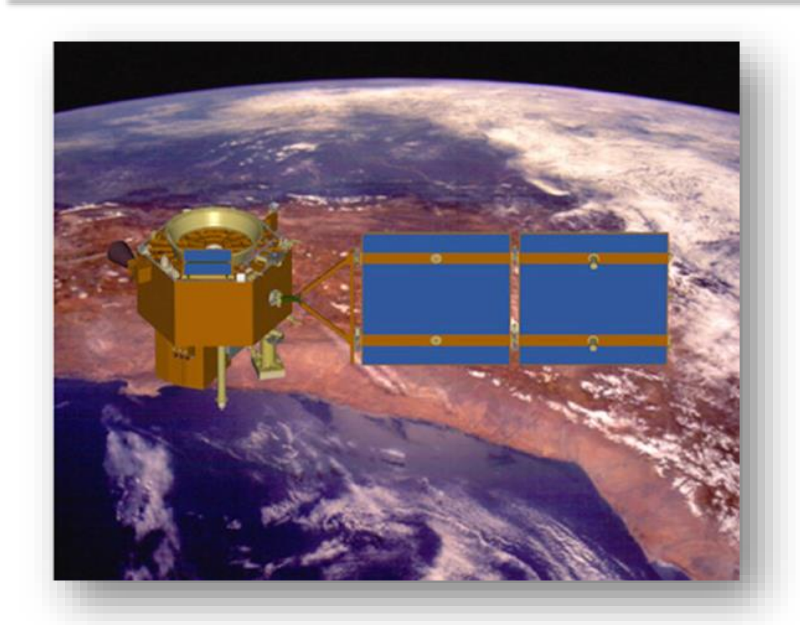
Reference

- AIAA-1999-3469

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EO-1 Propulsion System





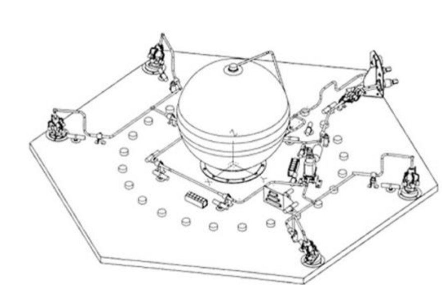
Item	QTY	Manufacture
Tank	1	PSI
1N (0.2 lbf) REA (MR103G)	4	Aerojet Rocketdyne
Fill/Drain Valve Fuel	1	Moog
Fill/Drain Valve GN2	1	Moog
Latch Valve	1	Moog
Pressure Transducer	1	Paine
Filter	-	Wintec, LLC

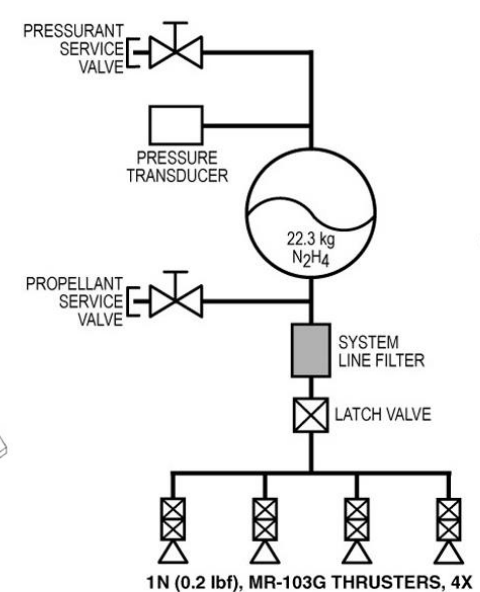
Performance Parameters
- Propellant Mass…22.3 kg (49 lbm)
- Total Impulse (per REA)…46,000 N-sec (10,428 lbf-sec) @ 21°C
- Pressure BOL/EOL…18.8/ 5.2 bar (273/76 psia) @ 21°C
- Blowdown Ratio…36:1

Status
- Flight Proven

Reference
- AIAA-2001-3637

Component Description
- See chart at top right



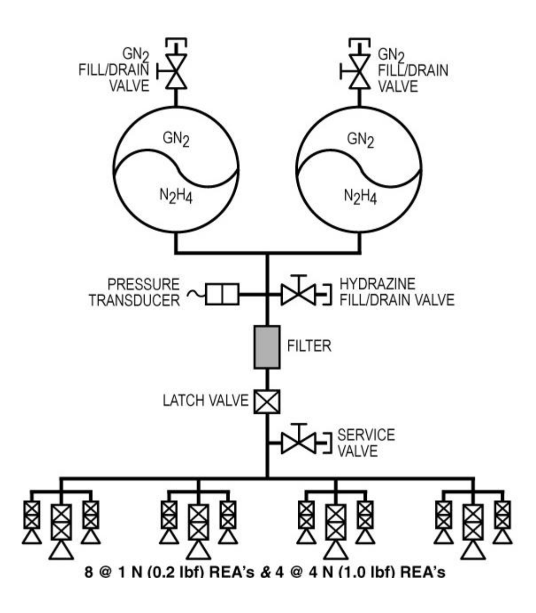


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MSTI-3 Propulsion Module







(Propulsion Schematic)

Performance Parameters

- Propellant Mass…. . . . . .22 kg (49 lbm)
- Total Impulse….. . . . . .42,000 N-sec (9500 lbf-sec)
- Pressure Mass…. . .. . 0.22kg (0.49 lbm)
- Pressure BOL/EOL…. . .22.7/ 6.2 bar (329/90 psia)
- Blowdown Ratio…. 3.7:1
- System Mass BOL/EOL…39.5/ 17.2 kg (87/38 lbm)

Status

- Flight Proven

Component Description

- See chart at right

Item	QTY	Manufacture
Tank	2	PSI
1N (0.2 lbf) REA (MR-103C)	8	Aerojet Rocketdyne
4N (1.0 lbf) REA (MR-111C)	4	Aerojet Rocketdyne
Fill/Drain Valve GN2	4	VACCO
Latch Valve	1	VALCOR
Pressure Transducer	1	Paine
Filter	1	VACCO

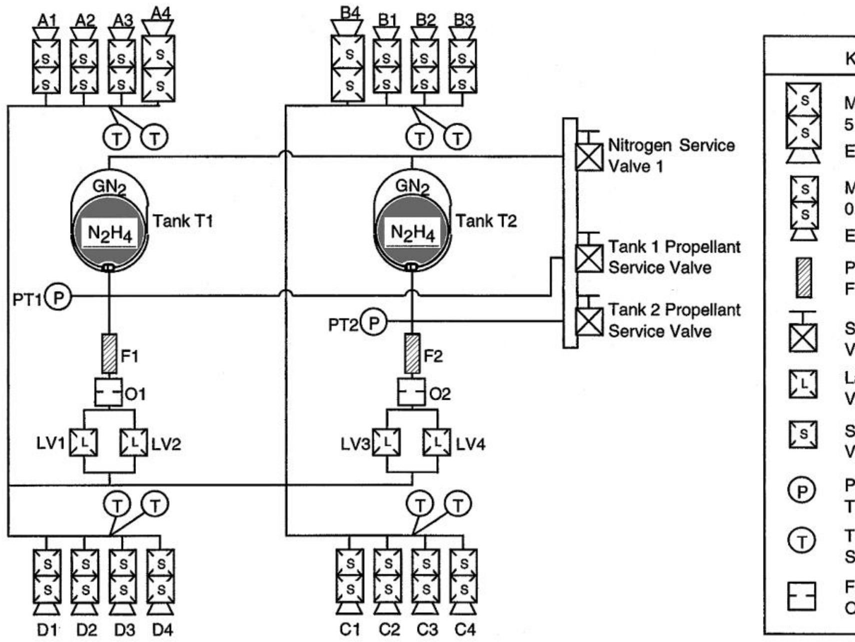
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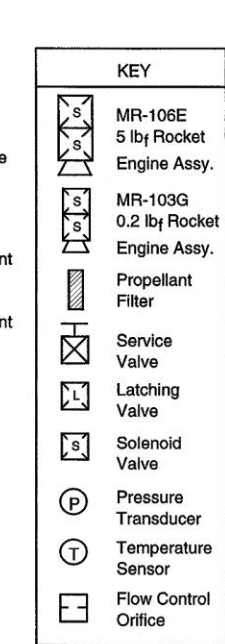
Comet Nucleus Tour (CONTOUR)









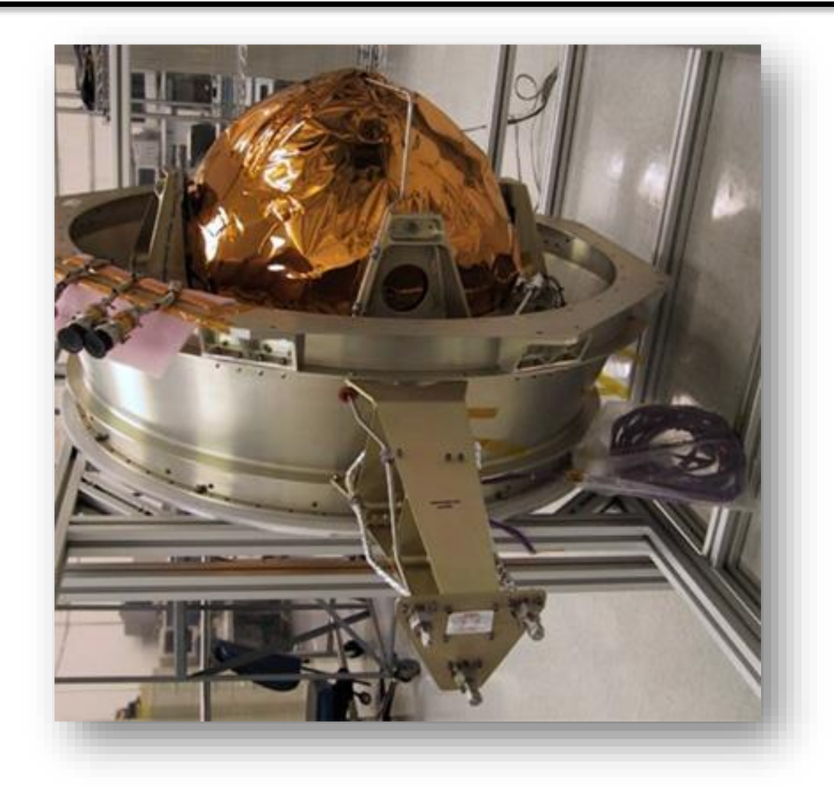


- Systems Flown: 1
- Propellant Load:165 lbm (90 kg) Hydrazine
- 350-125 psia (24.1-8.6 bar) Blowdown Operation
- 14 MR-103G 0.2-lbf (1 N) Thrusters
  2 MR-106E 5-lbf (22 N) Thrusters
- Used for Attitude Control (Interplanetary Spacecraft)
- Aerojet Integrated System on Customer-Supplied Structure

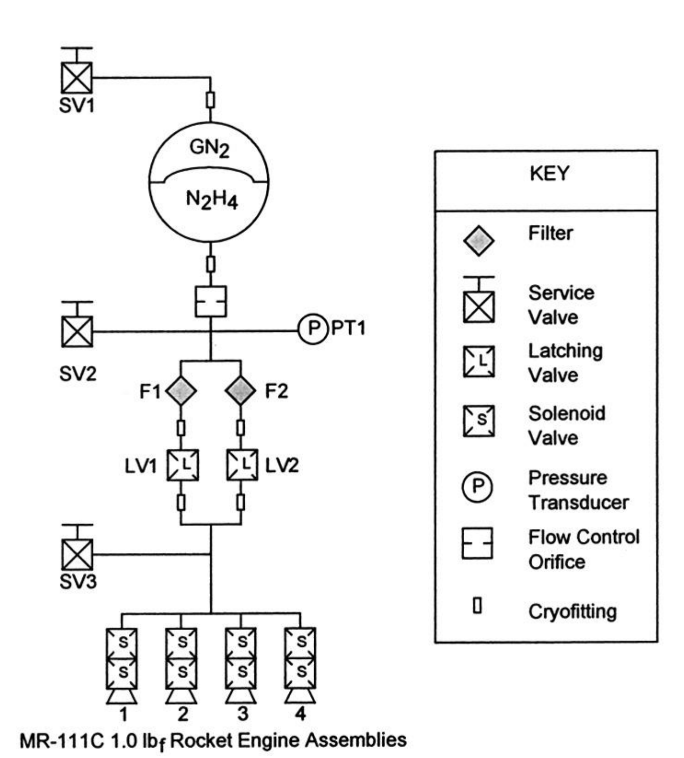
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Coriolis





- Systems Flown: 1
- Propellant Load:200 lbm (91 kg) Hydrazine
- 400-75 psia (27.5-5.2 bar) Blowdown Operation
- 4 MR-111C 1-lbf (4 N) Thrusters
- Used for Orbit Raising (LEO Spacecraft)
- Aerojet Integrated System and Secondary Structure on Customer-Supplied Primary Structure



(Coriolis HPS Schematic)

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Green & CubeSat Propulsion Systems



Green Propulsion and CubeSat Propulsion



GPIM

GR-1

GR-1A

MPS-130-1U

GR-M1

MPS-135-6U

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Modular Propulsion Systems





CubeSat Modular Propulsion Systems

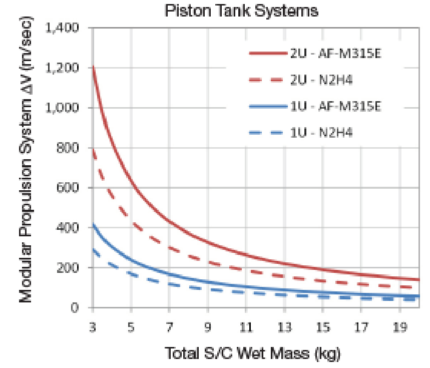
- High reliability, high delta-V propulsion for CubeSats and SmallSats
- Orbit maintenance, station keeping, and reaction control
- High density non-toxic green propellant and traditional hydrazine

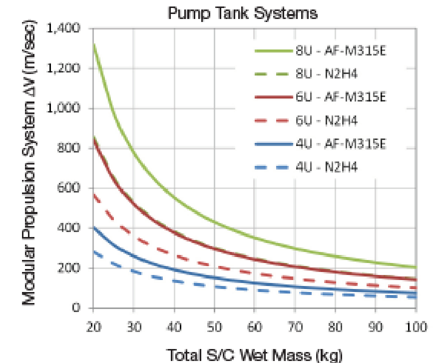
System Specifications

Thrust Range -0.25 – 1.0 N (per thruster)	1U	2U	4U	6U	8U
Green (AF-M315E)	**MPS-130-1U**	**MPS-130-2U**	**MPS-135-4U**	**MPS-135-6U**	**MPS-135-8U**
System Impulse* (N·s)	>1,130	>2,720	>7,290	>13,740	>19,360
System Dry Mass (kg)	1.1	1.4	3.5	4.3	5.1
System Wet Mass (kg)	1.7	2.8	7.2	11.2	14.7
Hydrazine	**MPS-120-1U**	**MPS-120-2U**	**MPS-125-4U**	**MPS-125-6U**	**MPS-125-8U**
System Impulse* (N·s)	>810	>1,960	>5,240	>9,890	>13,930
System Dry Mass (kg)	1.2	1.5	3.6	4.4	5.1
System Wet Mass (kg)	1.6	2.5	6.2	9.3	12.1

*System impulse based on steady state firing operation. Actual total impulse will vary based on operational duty cycles.

Performance Data





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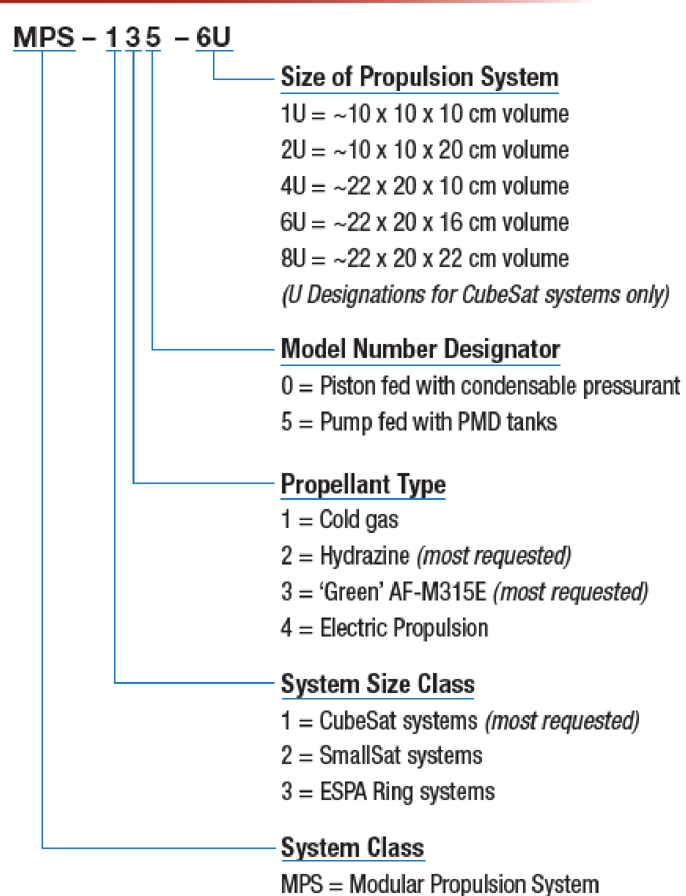
MPS Configuration Identifier



Innovative Propulsion Solutions for CubeSats and SmallSats

- High reliability, high delta-V propulsion for CubeSats and SmallSats
- Orbit maintenance, station keeping, and reaction control
- High density non-toxic green propellant and traditional hydrazine

Propulsion System Designations:



CubeSat Modular Propulsion System Configurations

Figure	Models
	MPS-130-1U MPS-120-1U
	MPS-130-2U MPS-120-2U
	MPS-135-4U MPS-125-4U
	MPS-135-6U MPS-125-6U
	MPS-135-8U MPS-125-8U

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Electric Propulsion



AR has delivered over 550 electric propulsion devices

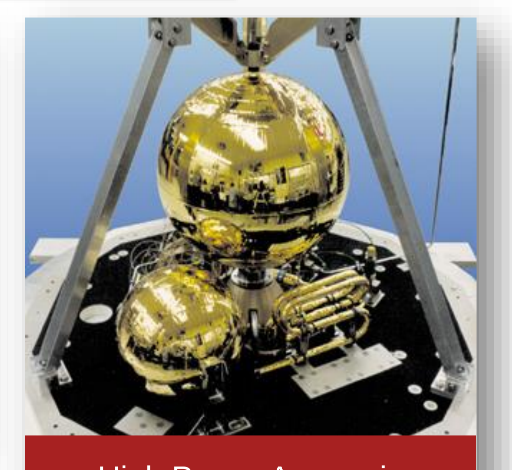




Electrothermal Hydrazine Thruster
And PPU / Arcjet and Feed System



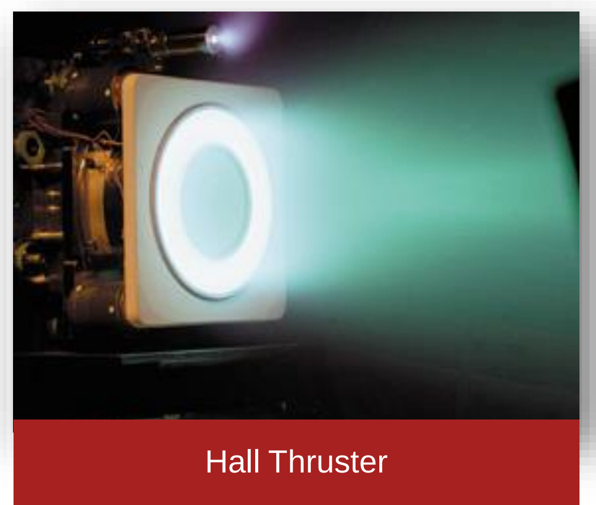
Hydrazine Arcjets
and Power Processing Unit /
Arcjet and Feed System



High Power Ammonia
Arcjet and Feed System



Pulsed Plasma Thruster



Hall Thruster



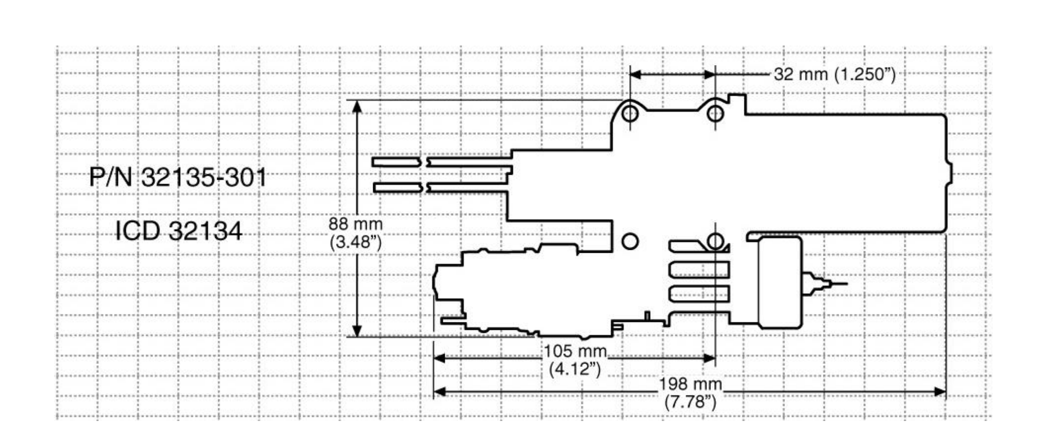
Xenon Ion Engine

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MR-502A Improved Electrothermal Hydrazine Thruster (IMPEHT)







Design Characteristics

Propellant………………………………………….…Hydrazine
Catalyst……………………………………………….…S405
Thrust/Steady State…..........…0.80 – 0.36N (0.18 – 0.08 lbf)
Feed Pressure………………...…26.5-6.2 bar (285 – 90 psia)
Flow Rate…………………0.28-0.12 g/sec (0.00026 lbm/sec)
Valve…………………………………………...…Dual Seat
Valve Power………………8.25 Watts Max @ 28 Vdc& 21°C
Valve Heater Power….....…1.54 Watts Max @ 28 Vdc& 21°C
Cat. Bed Heater Pwr…...…3.93 Watts Max @ 28 Vdc& 21°C
Augmentation Heater Pwr……………………885 – 610 Watts
Augmentation Htr Voltage……………..… 29.5 – Vdc Letdown
Mass……………………………………….…0.87 kg (1.92 lbm)

Performance

Mission Specific Impulse *
Steady-State Blowdown…………303 – 294 sec (lbf-sec/lbm)
Total Impulse……………….524,864 N-sec (118,000 lbf-sec)
Total Pulses……………….MR-502A not designed for pulsing
Steady State Firing…2 hrs Single Firing / 370 hrs Cumulative

Status

Flight Proven
In Production

Reference

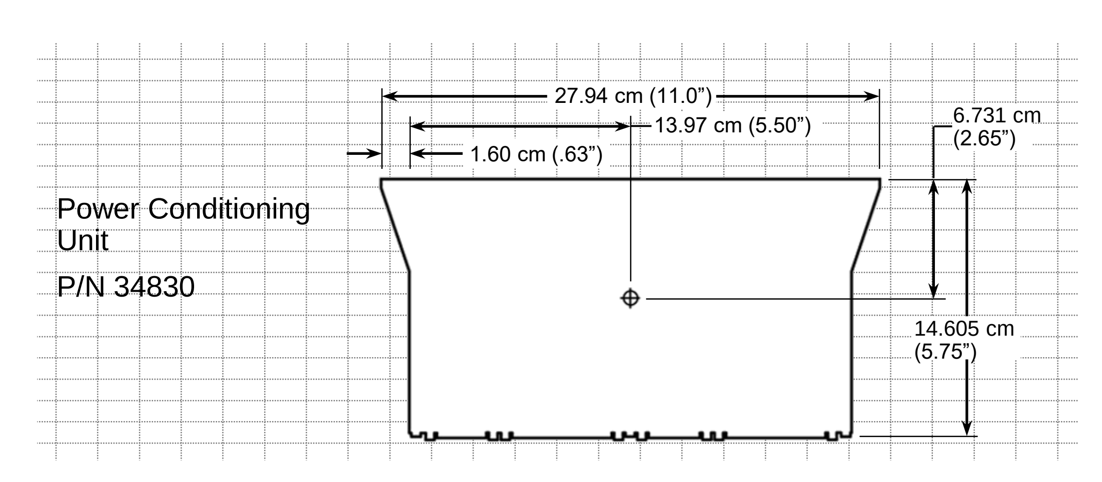
A1AA-1987-0996

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MR-502 & MR-502A IMPHET Power Conditioning Unit







Design Characteristics

- Mass . . . . 2 kg
- Envelope . . . . 27.94 x 9.42 x 14.61 cm
- Input Voltage . . . . .15-29.9 vdc
- Inrush Current . . . . 32 Amp Max
- Efficiency . . . . >97%

Interface

- Enable/Disable Command . . . . . . Latch Relay Drive
- On/Off Command . . . . 0V – Off, 14V – On

Demonstrated Performance

- Limits inrush current to the 30 Amps during augmentation heater warm-up
- Two identical independent channels that can be operated either redundantly or simultaneously
- When used simultaneously, the IMPEHT pair should be started one after the other

Status

- Flight Proven
- Not currently in production

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MR-509 Low Power Arcjet System





138 mm (5.43") MAX.
95 mm (3.75") MAX.
33 mm (1.30")
43 mm (1.70") MAX.

Design Characteristics

- Propellant:...High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal)………18.6 – 13.8 bar (270 – 200 psia)
- Mass ……………………………………………..……………………
  - Arcjet thruster + 2000 mm (70") cable ………1.4 kg (3.0 lbm)
  - PCU…………………………………………….6.2 kg (13.7 lbm)
- Envelope ……………………………………………………………
  - Arcjet……………...240 x 125 x 90 mm^3 (9.3 x 4.9 x 3.6 $inch^3$)
  - PCU………….….310 x 220 x 95 mm^3 (12.2 x 8.7 x 3.7 $inch^3$)
- Valve:……………………………dual seat, electrically actuated
- Valve power (standard)…………………………8.2 W @ 28 VDC
- PCU input power per arcjet…………………….………1780 W
- PCU input voltage……………………………………..65 - 96 VDC
- PCU efficiency, avg.…………………………………………>91%
- Power cable PCU – arcjet…………………...< 2000 mm (79 inch)
- Currently available…………………………..…..1575 mm (62 inch)

Demonstrated Performance

- At 1670 W input to the arcjet (1780 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down
- Total impulse…………………….....866,500 Ns (194,500 lbf s)
- Thrust……………………………254 – 213 mN (57 – 47 mlbf)
- Specific impulse…………………………………………..> 502 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off……………….> 1050 cycles
  - Number of starts……………………………..…………..>1170
- Longest demonstrated burn:………………………………..65 h

Status

- Flight proven, no longer in production

References

- AIAA-1998-3631
- IEEPC-1997-081

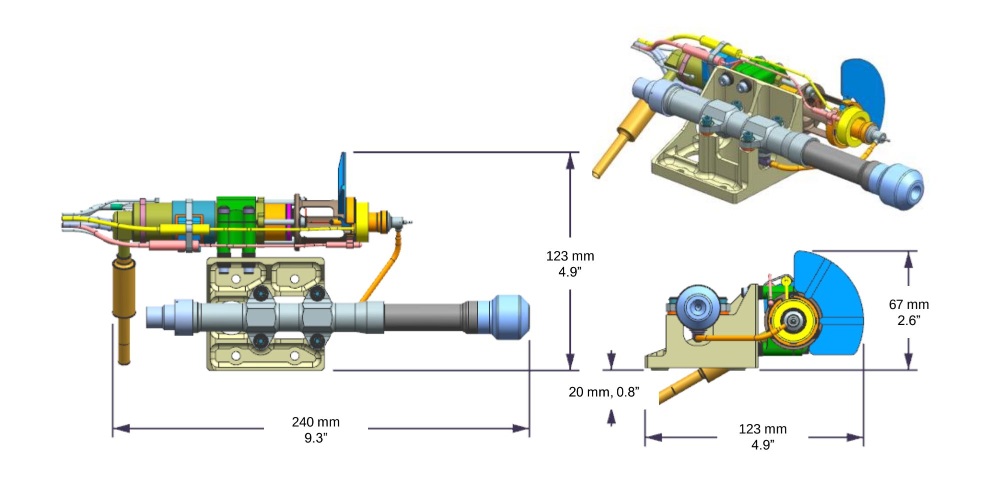
- *Power Conditioning Unit (PN 1000)*
- *Cable Assembly (PN 31168)*
- *Arcjet Thruster (PN 32240)*

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MR-510 Arcjet Thruster and Cable Assembly







Design Characteristics

- Propellant:...High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal).........18.6 – 13.8 bar (270 – 200 psia)
- Mass:
  - Arcjet thruster + 3175 mm (125") cable ......1.6 kg (3.5 lbm)
- Envelope
  - Arcjet.................240 x 123 x 87 mm^3 (9.3 x 4.9 x 3.4 $inch^3$)
- Valve:.................................dual seat, electrically actuated
- Valve power (standard)..............................8.2 W @ 28 VDC
- Power cable PCU – arcjet....................< 5590 mm (220 inch)

Status

- Flight proven
- Recent production

Demonstrated Performance

At 2000 W input to the arcjet (2200 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down

- Total impulse..........................1,450,000 Ns (326,000 lbf s)
- Thrust...................................258 – 222 mN (58 – 50 mlbf)
- Specific impulse...585 - 615 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off....................> 1730 cycles
  - Number of starts..>1960
- Demonstrated on-time duty cycles:....................4 min to 20 h

References

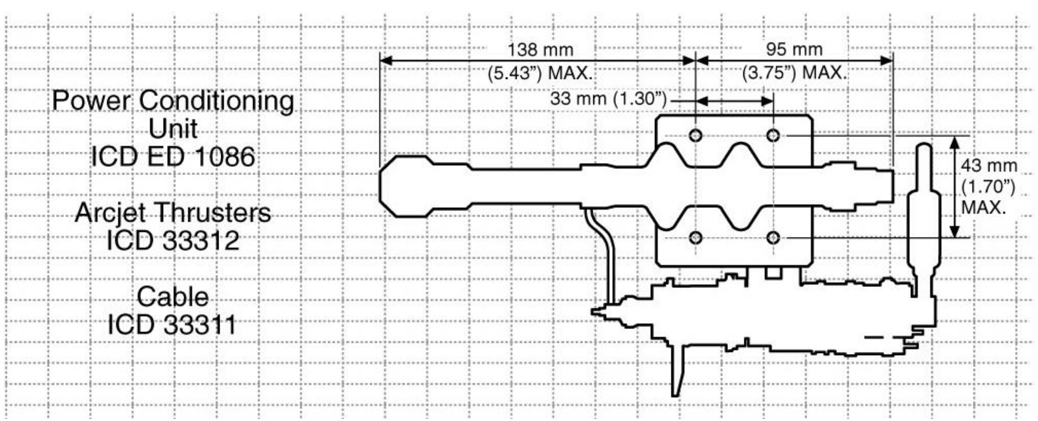
- AIAA-1998-3630, AIAA-1999-2272, AIAA-2001-3901, AIAA-2009-5364, IEPC-1997-082, esa SP2014-2966753, IEPC-2017-305

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MR-512 Low Power Bus Arcjet System







Design Characteristics

- Propellant:...High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal)………17.6 – 13.8 bar (250 – 200 psia)
- Mass:
  - Arcjet thruster + 2000 mm (70") cable ………1.4 kg (3.0 lbm)
  - PCU……………………………………………6.2 kg (13.7 lbm)
- Envelope
  - Arcjet……………..240 x 125 x 90 mm^3 (9.3 x 4.9 x 3.6 inch^3)
  - PCU…………310 x 220 x 95 mm^3 (12.2 x 8.7 x 3.7 inch^3)
- Valve:………………………………dual seat, electrically actuated
- Valve power (standard)…………………………8.2 W @ 28 VDC
- PCU input power per arcjet…………………………………1780 W
- PCU input voltage………………………………33 – 51.5 VDC
- PCU efficiency, avg.…………………………………………>91%
- Power cable PCU – arcjet…………………< 2000 mm (79 inch)
- Currently available……………………………..1575 mm (62 inch)

Demonstrated Performance

At 1670 W input to the arcjet (1780 W input to the PCU), and 270 to 200 psia feed pressure blow down

- Total impulse …………………866,500 Ns (194,500 lbf s)
- Thrust…………………………254 – 213 mN (57 – 47 mlbf)
- Specific impulse ………………………………….> 502 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off …………> 1050 cycles
  - Number of starts…………………………………….>1170
- Longest demonstrated burn:……………………………..65 h

Status

- Flight proven, no longer in production

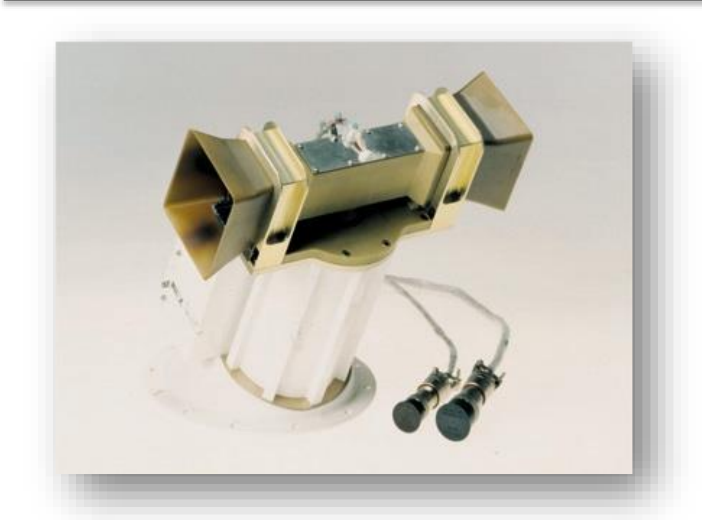
References

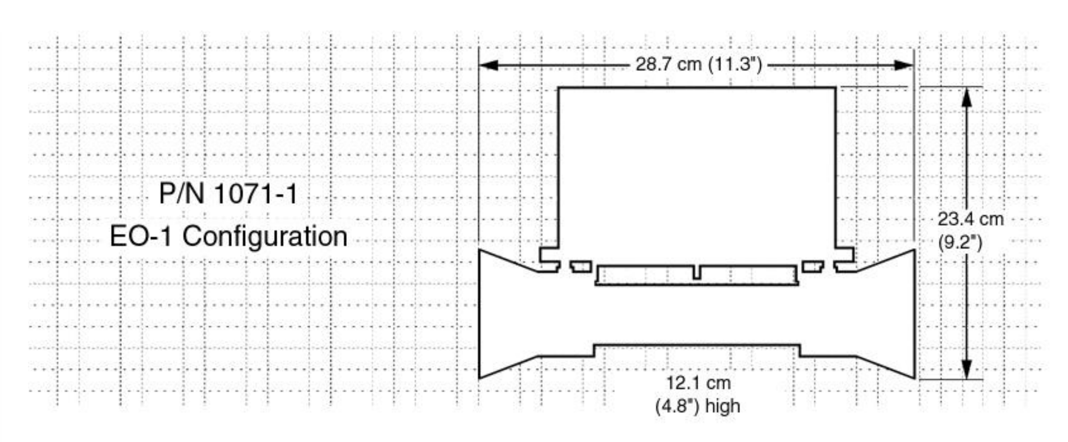
- AIAA-1998-3631
- IEPC-1997-081

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PRS-101 Pulsed Plasma Thruster System







Design Characteristics

- Propellant . . . . Teflon® (Solid Bar)
- Max Thrust Level1 . . . . 1.24 mN @ 100 Watts
- Power Level . . . .
- . . . . Up to 100 Watts @ 28 vdc Unregulated
- Compact Solid State Propulsion System
- Ultra Low Minimum Impulse Bit for Precision Control
- Enables All-thruster ACS (No Momentum Wheels)
- Mass (w/o propellant) . . . . 4.74 kg
- Includes Integral Power Processing Electronics
- Power Efficiency . . . . >80%

Performance

- Specific Impulse . . . . Up to 1350 sec
- Thrust to Power Ratio . . . . 12.4 μN/Watt
- Demonstrated Capability. . . . . . . .3,000 N-sec/thruster
- Predicted Capability (backed by selective testing) . . . .
- . . . . 15,600 N-sec/system (thruster pair)

Status

- Flight Proven; no longer in production

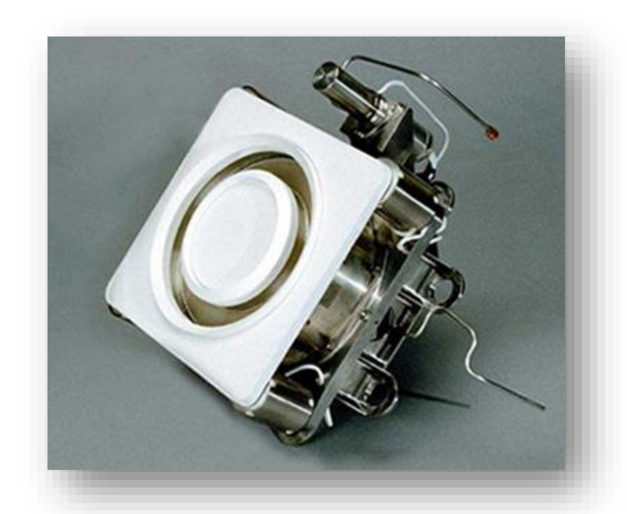
Reference

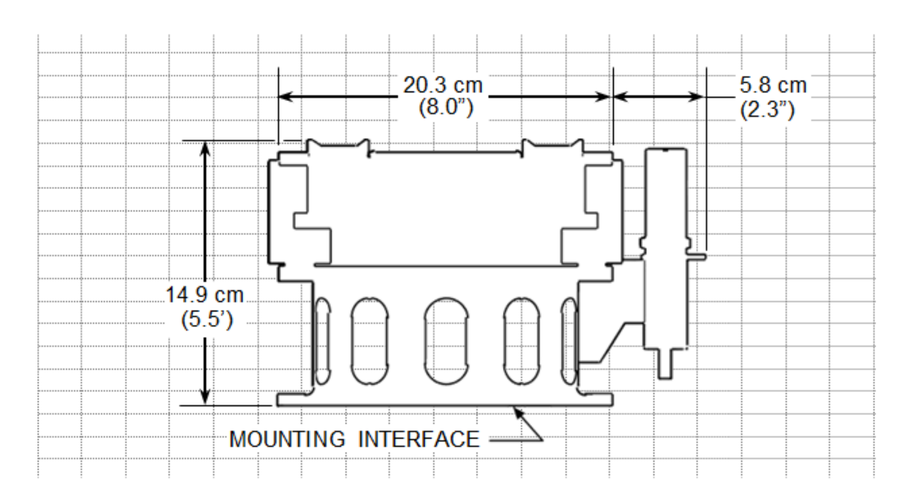
- AIAA-2003-5016
- AIAA-2002-3973
- AIAA-2001-3637
- AIAA-1999-3376

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XR-5 Hall Thruster







Design Characteristics

- Propellant . . . . Xenon
- Mass (Thruster & Cathode) . . . . <12.3 kg
- Envelope . . . . 14 x 25 x 28 cm
- Input Power . . . . 1000 to 4500 Watt
- Input Voltage . . . . 200 or 400 Volt

Status

- Qualification Complete; 24 Thrusters Flown
- First flight system launched in 2010
- Six spacecraft currently flying (4 thrusters per S/C)

Performance

	2.0 kW	*3.0 kW*	*4.5 kW*
Thrust (300 Volts)	132 mN	195 mN	290 mN
Thrust(400 Volts)	117 mN	170 mN	254 mN
Specific Impulse (300 V)	1676 sec	1700 sec	1790 sec
Specific Impulse (400 V)	1858 sec	1920 sec	2020 sec

- Life Capability . . . . Mission Dependent
- Total Impulse . . . . Mission Dependent
- On/Off Cycles . . . . 7,316 Cycles

Status

- Flight Proven, In Production

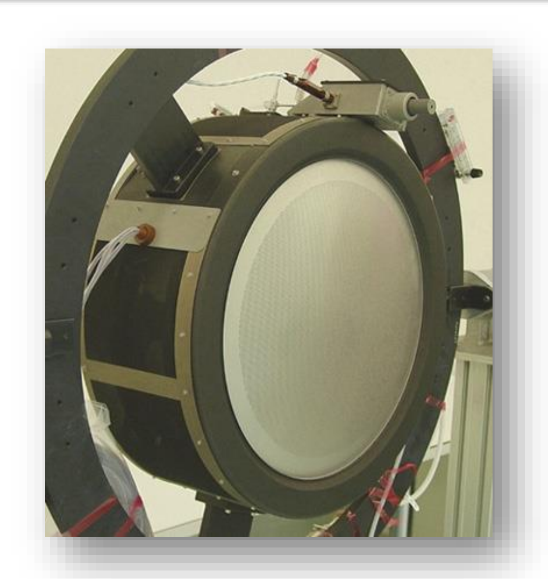
Reference

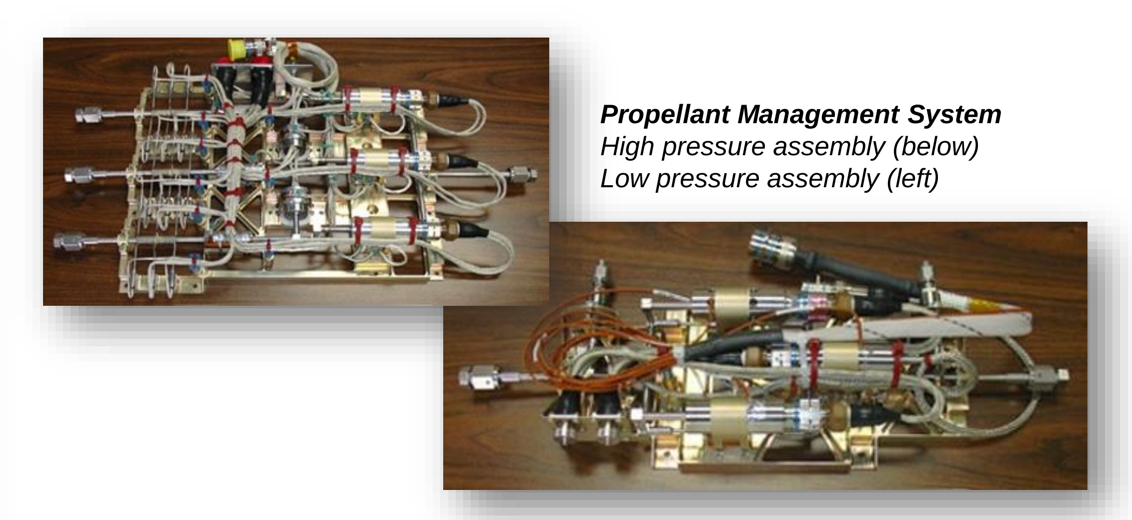
- AIAA-2010-6698

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NEXT 6.9 kW Ion Propulsion System







Propellant Management System
High pressure assembly (below)
Low pressure assembly (left)

Design Characteristics

- Propellant …………………………..………… Xenon
- Thruster Mass……..…………...……….…. <13.3 kg
- Thruster Envelope Dimensions...…. 58 dia. x 44 cm
  - Active optics area……..……………...36 cm dia.
- Thruster Input Power ……………..600 to 6900 Watt
- Propellant Management System Mass
  - High Pressure Assembly……………….< 2.2 kg
  - Low Pressure Assembly………………..< 4.1 kg
- PMS Volume …………………………..…..< 11,775 c.c.
  - *PMS does not require plenum tanks*
- DCIU interface with Power Processing……..RS-485

Performance

- Thrust …………………………………...………… 235 mN
- Specific Impulse…………………………...……… >4100 sec
- Efficiency @ full power ………………….....………… >70%
- Propellant Throughput……... ………...……….. >270 kg
- On/Off Cycles ………………………..…….….. >3650 cycles
- End of Life Xenon Residuals ……….………….. < 1% BOL

Status

- Qualified and in Production; First Flight DART mission

Reference

- AIAA-2005-3885
- AIAA-2004-4111

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Electric Propulsion Power Electronics



Electric Propulsion Power Electronics




TELSTAR 4/Series 7000 1.8 kW Power Conditioner



A2100 4.4 kW Power Conditioner


DRTS 1.8 kW Power Conditioner


AATD 30 kW Power Conditioner


A2100 Power Relay Box


NRL EPDM 1.5 kW Power Conditioner


EHT/IMPEHT Controller


EO-1 High Voltage Power Conditioner

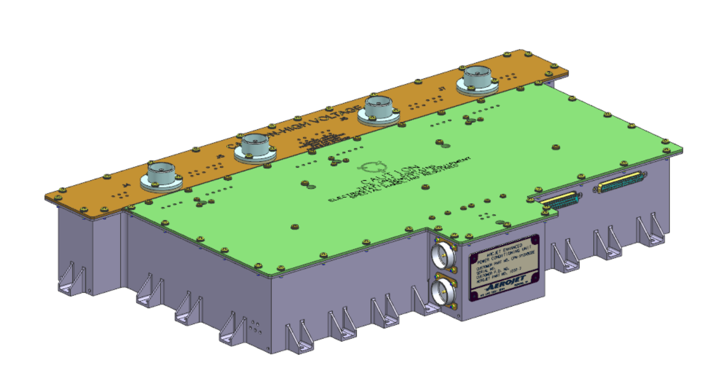

Hall Thruster Propulsion System 4.5 kW PPU

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MR-510 Arcjet Power Conditioning Unit (PCU), 70 VDC Input







Design Characteristics

- 3 independent power converters, 2 of which can be operated simultaneously
- Output can be switched between four different arcjets
- Redundant control circuitry and auxiliary power supplies
- Serial telemetry format; for other formats, contact Aerojet Rocketdyne
- Includes “Bubble Protection Mode” to mitigate gas induced shutdowns
- Calculated reliability for 15 years of GEO COMSAT use >0.99994
- Telemetry signals provided by the PCU:
    - Arc voltage and current
    - PCU status flags
- Mass……………………………………….15.8 kg (34.8 lbm)
- Envelope……635 x 360 x 110 mm³ (24.9 x 14.2 x 4.3 inch³)

(*Design Characteristics Continued)*

- Efficiency (avg.)…………………………………………> 91%
- Heat rejection (two arcjets at 2040 W), to be dissipated by the spacecraft thermal management system..........<410 W @ 23°C
- Selectable output power levels for each converter
  1530 W, 1700 W, 1870 W, 2040 W
- Input power when operating two converters at 2040 W….4430 W

Status

- Flight Proven; Recent Production

References

- AIAA-1998-3630, AIAA-1999-2272, AIAA-2001-3901, AIAA-2009-5364, IEPC-1997-082, esa SP2014-2966753

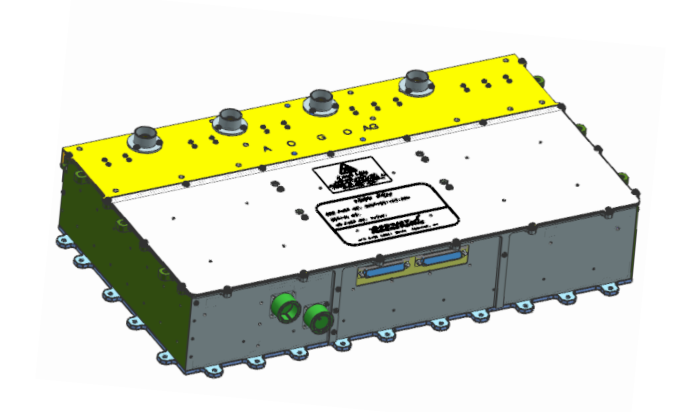
- *Power Conditioning Unit (PN 1037)*

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MR-510 Arcjet System Power Conditioning Unit (PCU), 100 VDC Input







Design Characteristics

- 3 independent power converters, 2 of which can be operated simultaneously
- Output can be switched between four different arcjets
- Redundant control circuitry and auxiliary power supplies
- Serial telemetry format; for other formats, contact Aerojet Rocketdyne
- Includes “Bubble Protection Mode” to mitigate gas induced shutdowns
- Calculated reliability for 15 years of GEO COMSAT use >0.99994
- Telemetry signals provided by the PCU:
    - Arc voltage and current
    - PCU status flags
- Mass……..…………………………………19.1 kg (42.1 lbm)
- Envelope..……630 x 375 x 130 mm^3 (24.8 x 14.8 x 5.1 $inch^3$)

(Design Characteristics Continued)

- Efficiency ……………………………………………..………> 87%
- Heat rejection (two arcjets operating at 2040 W) to be dissipated by the spacecraft thermal management system.............<470 W
- Selectable output power levels for each converter............ . . . . . ………………………………1530 W, 1700 W, 1870 W, 2040 W
- Input power when operating two converters at 2040 W….4550 W

Status

- Flight Proven; Recent Production

References

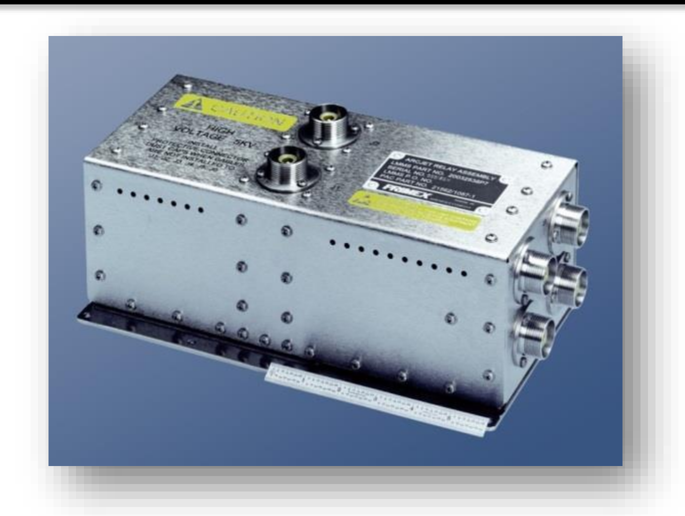
- AIAA-1998-3630, AIAA-1999-2272, AIAA-2001-3901, AIAA-2009-5364, IEPC-1997-082, esa SP2014-2966753

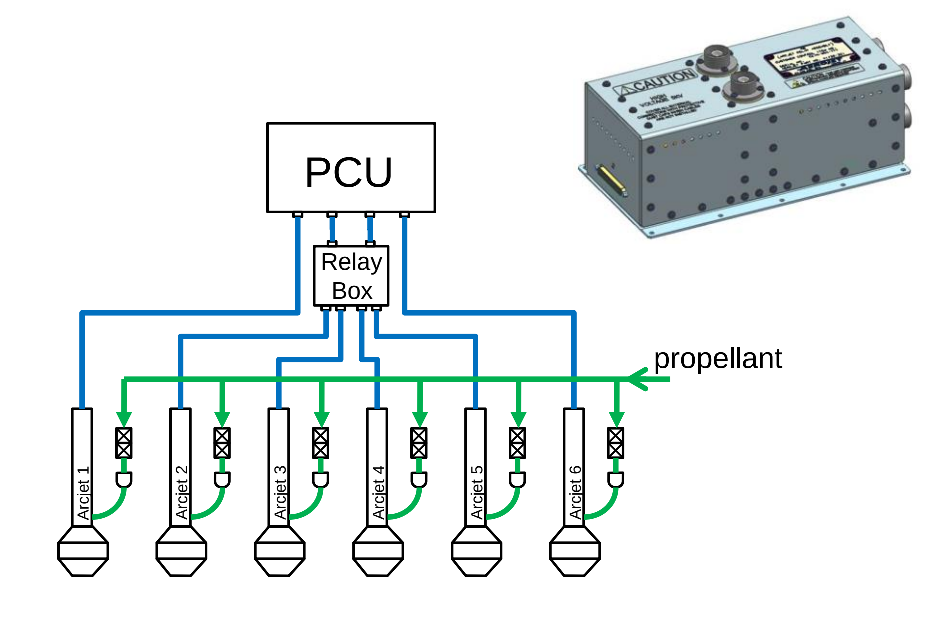
- *Power Conditioning Unit (PN 41540)*

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MR-510 Arcjet System Relay Box







Design Characteristics

- Allows expansion of the MR-510 arcjet system from 1 PCU and 4 arcjets to 1 PCU and 6 (1 relay box) or 8 (2 relay boxes) arcjets
- Connects two PCU arcjet outputs to two each arcjets
- Calculated reliability for 15 years of GEO COMSAT use >0.99994
- Telemetry signals provided by the PCU:
    - Verification of relay position
    - Temperatures internal to the relay box
- Mass ……………………………………………2.2 kg (4.8 lbm)
- Envelope………333 x 168 x 137 mm^3 (13.1 x 6.6 x 5.4 $inch^3$)
- Total cable length PCU to relay box to arcjet: ……………………………not to exceed 5590 mm (220 inch)
- Currently, two PCU to relay box power cable lengths are available………………………1070 & 1625 mm (42 & 65 inch)

Status

- Flight Proven; Recent Production

References

- AIAA-1999-2272, AIAA-2001-3901, AIAA-2009-5364, esa SP2014-2966753, IEPC-2017-305

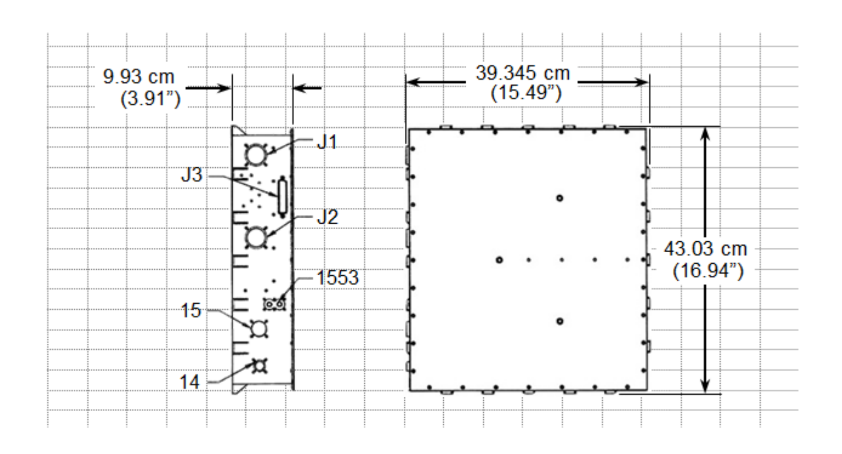
- *Relay Box (PN 41430)*

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XR-5 4.5 kW Hall Thruster Power Processor Unit







Design Characteristics

- Mass . . . . 12.5 kg
- Envelope . . . . 43 x 40 x 11 cm
- Input Voltage . . . . 70 +/- 2 VDC
- Efficiency (Avg) . . . . >92%
- MIL-STD-1553 Command & Telemetry Interface:
- 30 Telemetry Channels
- Commandable Power Settings:
- Discharge Power . . . . 2.0 - 4.5 kW
- Discharge Voltage . . . . 150 - 400 V

Demonstrated Performance

- Closed Loop Control of Xenon Flow Controller and Discharge Current
- Holding Valve Drivers
- S-Level, Radiation Hardened Components
- Optimized for Manufacturability
- Only Four Circuit Cards

Status

- Flight Proven; Recent Production

Reference

- AIAA-2005-3682

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